DIFFUSION OF INNOVATION: KNOWLEDGE AND ATTITUDES OF ONCLOGY NURSES REGARDING PHARMACOGENOMIC TESTING

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ABSTRACT

CRYSTAL DODSON: Diffusion of Innovation: Knowledge and Attitudes of Oncology Nurses Regarding Pharmacogenomic Testing
(Under the direction of Marcia Van Riper, PhD, RN, FAAN)

There are currently over 20 different pharmacogenomic tests being used in the oncology field. However, only a few studies have been conducted regarding knowledge and attitudes towards pharmacogenomic testing among clinicians, in particular nursing. This descriptive study (guided by Rogers' Diffusion of Innovation Theory) utilizing descriptive statistics and variable selection methods was conducted with 368 oncology nurses in the state of North Carolina to identify and test key elements of Rogers' Diffusion of Innovation theory that play a role in the adoption of pharmacogenomic testing into the oncology practice by assessing oncology nurses knowledge, attitudes, and support for use of pharmacogenomic testing.

Oncology nurses who participated in this study had a low perception of their knowledge of both genomics and pharmacogenomic testing based on their perceived knowledge. Additionally, attitudes towards pharmacogenomic testing were overall positive. Attitudes toward pharmacogenomic testing specifically related to oncology had a more favorable response than attitudes towards pharmacogenomic testing in general. Furthermore, the study revealed that oncology nurses in this study utilize pharmacogenomic testing information routinely in their nursing care.

Variable selection methods revealed that total genomic knowledge was more accurately predicted by prior experience and personality variables. Secondly, basic genomic knowledge was more accurately predicted by prior experience, ruralality, perceived need of pharmacogenomic testing, and personality variables. Furthermore, pharmacogenomic knowledge was more accurately predicted by personality variables. Moreover, attitude towards pharmacogenomic testing was more accurately predicted by communication behavior, prior experience, perceived need and characteristics of the innovation. Finally, support for use was accurately predicted by perceived genomic knowledge.

Based on these findings, several factors play a key role in the diffusion of pharmacogenomic testing within the oncology nursing field. Therefore, assessment of these variables may benefit the widespread adoption of pharmacogenomic testing. Further research should be conducted with these variables in order to assess the adoption of this innovation.

DEDICATION

To my wonderful and loving husband, Chad Dodson

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ABBREVIATIONS

AIC	Akaike Information Criterion
ANOVA	Analysis of Variance
APRN	Advanced Practice Registered Nurse
BIC	Bayesian Information Criterion
DNA	Deoxyribonucleic Acid
DNP	Doctorate of Nursing Practice
FDA	Food and Drug Administration
KAQ-PGx	Knowledge, Attitude, and Support for Use Questionnaire-Pharmacogenomic Testing
LPN	Licensed Practical Nurse
NPQ-PGx	Nursing Practice Questionnaire-Pharmacogenomic Testing
PG	Pharmacogenomic
PRESS	Predicted Residual Sums of Squares
RN	Registered Nurse
RNA	Ribonucleic Acid

Chapter I

Introduction

During the past few decades there has been a dramatic increase in genomic testing. The term genomic testing covers a wide array of sophisticated techniques including direct examination of DNA, RNA, or protein (National Human Genome Research Institute, 2012). According to the GeneTests website, a publically funded medical genomics information resource, genomic testing is currently available for over 2,500 diseases in the clinical setting (University of Washington, 2012). In addition, testing for another 240 diseases is being carried out in research settings. Consequently, genomic testing will soon become available for a growing number of diseases.

Genomic testing can be utilized for a multitude of reasons including confirmation of a suspected diagnosis, detection of the presence of a carrier state in individuals who appear unaffected, screening or diagnostic testing for genomic conditions in embryos, fetuses, and newborns, and prediction of a patient's response to different types of therapy (National Human Genome Research Institute, 2012). Pharmacogenomic testing is a particular type of genomic testing that is used to guide a patient's drug therapy based on the individual's genomic make-up (Foley & Quigley, 2010). The utilization of pharmacogenomic testing allows for the assessment of drug toxicity and effectiveness prior to the initiation of a specific drug (Benhaim, Labonte, & Lenz, 2012; Kitzmiller, Groen, Phelps, & Sadee, 2011; McLeod, 2004). Pharmacogenomic testing is similar to other genomic tests in that it can be performed on a sample of blood or a buccal swab

(National Institute of General Medical Sciences, 2012). In addition, the techniques used to test for pharmacogenomic polymorphisms and genomic mutations are fundamentally the same as technique used in other types of genomic testing. However, which populations are targeted and how test results are interpreted and utilized can be quite different. For example, pharmacogenomic testing is only appropriate for patients who are candidates for treatment with particular medications (U.S. Food and Drug Administration, 2011), while other types of genomic testing are often considered appropriate for the general population.

Several healthcare fields are currently benefiting from the use of pharmacogenomic testing. One in particular is oncology. At this time, there are over 20 different pharmacogenomic tests being used in oncology (U.S. Food and Drug Administration, 2012). Pharmacogenomic tests are divided into two categories within the oncology field, ones that test for chemotherapy toxicity and ones that test responsiveness to treatment such as in tumor profiling (Genomic Diagnostic Network, 2012). Commonly used oncology drugs with pharmacogenomic testing information included in their package inserts are: Trastuzumab, Tamoxifen, Cetuximab, Vemurafenib, and Imatinib (U.S. Food and Drug Administration, 2012).

On an annual basis, an estimated 1 out of every 7 in-patient hospitalizations experience an adverse drug reaction (Davies et al., 2009). In addition, it has been reported that an adverse drug reaction is the fourth to sixth leading cause of mortality in the United States (Vora, Trivedi, Shah, & Tripathi, 2011). The pervasiveness of adverse drug reactions is often thought to be the consequence of a one-size-fits-all philosophy in prescribing medications (Marsh & McLeod, 2006; Swen et al., 2007). Therefore, in

recent years many researchers and clinicians have begun recommending a shift to individualized drug therapy. Individualized drug therapy is an approach in which a patient's genomic profile is used to guide the type and amount of medication the patient receives (Hamburg & Collins, 2010; Roederer, Van Riper, Roederer, McLeod, & Evans, 2012). There is growing evidence that adverse reactions can be decreased when a patient's dosage of medication is based on their genomic profile (Amur, Zineh, Abernethy, Huang, & Lesko, 2010; Anderson et al., 2007, Becquemont, 2009; Manolopoulos, 2007; Phillips et al., 2001).

Statement of the Problem

Pharmacogenomic testing is becoming a routine part of practice in some areas but in others areas this is not the case (Ferraldeschi & Newman, 2011; Mutsatsa & Currid, 2012). The integration of pharmacogenomic testing into clinical practice ultimately depends on acceptance of and requests for pharmacogenomic testing by clinicians and patients (Rogausch , Prause, Schallenberg, Brockmoller, & Himmel, 2006). Clinicians who have limited awareness of pharmacogenomic testing or lack an adequate understanding of the potential benefits of pharmacogenomic testing are less likely to have favorable attitudes about pharmacogenomic testing (Ghaddar, Cascorbi, & Zgheib, 2011). Other factors that may influence attitudes about pharmacogenomic testing include access to genomic specialists, availability of educational resources about pharmacogenomic testing, and the existence of well-defined clinical guidelines (Haga, Tindall, & O'Daniel, 2012).

Currently, a few studies have been conducted regarding knowledge of and attitudes towards pharmacogenomic testing among clinicians (Haga et al., 2012,

Rogausch et al., 2006). However, the studies that do exist suggest that while some clinicians view their understanding of pharmacogenomics to be good, the majority do not. A nationwide survey of 10,303 physicians revealed that only 10.3% felt adequately informed about pharmacogenomics (Stanek et al., 2012). In contrast, a case study revealed that the four study participants whom were interviewed felt that pharmacists had a good understanding of pharmacogenomic testing (El-Ibiary, Cheng, & Alldredge, 2008). Moreover, in a study that included over 2000 clinicians and students from a variety of disciplines including pharmacy, nursing, and medicine, most of the participants described their knowledge of pharmacogenomic testing to be fair (44%) or poor (34%). In addition, on the 5 knowledge-based questions about pharmacogenomic testing about more than half of study answered the majority of questions correctly (Van Riper et al., 2012).

Findings from studies about attitudes towards pharmacogenomic testing suggest that many clinicians have ethical concerns. Some of the most commonly reported ethical concerns about pharmacogenomic testing are concerns about discrimination, lack of privacy, and failure to obtain informed consent (Avard, Silverstein, Sillon, & Joly, 2009; Egalite, Ozdemir, & Godard, 2007; Haga et al., 2011; Hedgecoe, 2006; Roederer et al., 2012; Rogausch et al., 2006; Tamaoki, Gushima, & Tsutani, 2007; Van Riper et al., 2012). However, positive attitudes towards pharmacogenomic testing were also reported. The advantages of pharmacogenomic testing acknowledged by clinicians were a reduction in adverse drug reactions and better clinical outcomes (Avard et al., 2009; Egalite et al., 2007; Fargher et al., 2007; Hoop, Lapid, Paulson, & Roberts, 2010; Mrazek et al., 2007; Roederer et al., 2012; Rogausch et al., 2006; Tamaoki et al., 2007; Van Riper

et al., 2012). In addition, two studies revealed that clinicians are more apt to use these tests because of the improved predictive accuracy of the prescribed drugs (Haga et al., 2011; Payne et al., 2011). According to the literature, clinicians have varying attitudes towards pharmacogenomic testing which may be related to the uncertainty of new innovations that have promising outcomes.

Many barriers have been linked to the successful adoption of pharmacogenomic testing into practice. Some of these barriers include lack of clinicians' awareness or knowledge, lack of counselors available, cost-effectiveness of this type of testing, substandard ethical regulations on genomic information, and inadequate evidence based outcomes relating to this type of testing (Ghaddar et al., 2011; Haga et al., 2011; Schnoll & Shields, 2011; Squassina et al., 2010). However, one study revealed that clinicians did not feel that inferior ethical regulations were a barrier to the implementation of pharmacogenomic testing (Ghaddar et al., 2011). Additionally, a study with third year medical students revealed that they were not concerned with ethical barriers; however, the plan for disclosure to patients varied greatly among these respondents (Zgheib, Arawi, Mahfouz, & Sabra, 2011). Based on the literature, these barriers may play a role in the successful adoption of pharmacogenomic testing.

In summary, lack of knowledge about and variable attitudes towards pharmacogenomic testing seem to permeate the healthcare field. However, few studies currently exist on this topic and most have not been conducted with nurses. Additionally, there has only been one published study about attitudes toward pharmacogenomic testing among professionals within the oncology field (Hedgecoe, 2006). Moreover, there have been no published studies concerning the knowledge of oncology clinicians related to

pharmacogenomic testing. Information obtained from a systematic review of the empirical literature revealed that there is a significant gap pertaining to the attitudes and understanding of pharmacogenomic testing within the oncology nursing population. Due to the relation between knowledge, attitudes, and adoption of pharmacogenomic testing, a study focusing on the assessment of knowledge and attitudes as it relates to support for use of pharmacogenomic testing within the oncology nursing population was conducted.

Theoretical Framework

Everett Rogers' Diffusion of Innovation theory provided the framework for examining the process of adoption and diffusion of pharmacogenomic testing among oncology nurses (Rogers, 2003). An innovation is defined as an idea, practice, or object that is perceived as new by an individual (Rogers, 2003). Adoption of an innovation is a decision-making process in which the individual first passes from initial knowledge of the innovation to forming an attitude toward this innovation, to a decision to either accept or reject it, or wait to make a decision at a later date. Factors that influence this decision are of utmost importance because this decision leads to the utilization of the innovation into practice. The stages of adoption and diffusion of an innovation are shown in Figure 1.

The first step in the adoption of an innovation is the initial knowledge about the innovation (Rogers, 2003). According to Rogers' (2003), there are several antecedents that affect how knowledge is received such as prior experience, perceived need of the innovation, general attitude towards change, personality variables such as age and educational level, demographic variables, communication behavior, and the work environment of the individual.

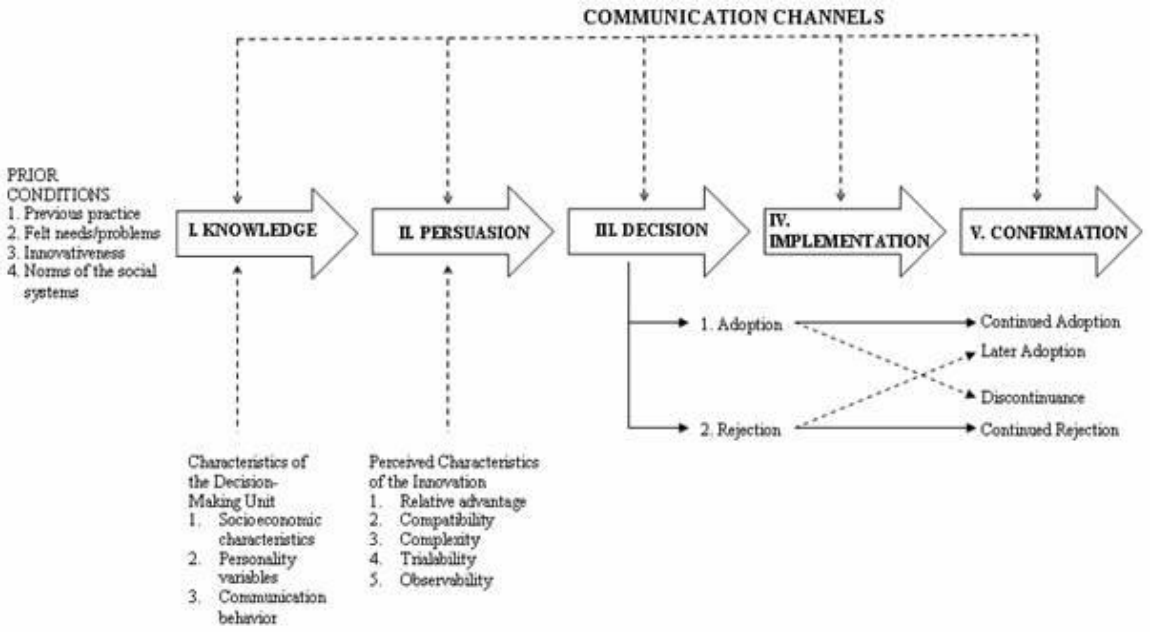


Figure 1: Rogers' Diffusion of Innovation framework. This figure displays the stages of this framework.

The awareness of the innovation then motivates the individual to gain more information about the topic. However, knowledge of the innovation does not automatically lead to adoption due to the fact that the individual must be persuaded to accept the innovation. The decision to adopt the innovation relies on the attitude of the individual concerning the innovation. Certain characteristics such as relative advantage, complexity, compatibility, trialability, and observability influence the individual's attitude toward the innovation (Rogers, 2003). Once a decision has been made to adopt it, the innovation is put into use and finally an evaluation of the innovation is completed.

This theory proposed a helpful way of assessing factors that may influence the diffusion of an innovation such as pharmacogenomic testing. The theory provided several factors of the decision-making process to consider as critical inputs that have the

potential to influence the adoption process of the innovation. These factors were utilized in the creation of specific variables to target within this study.

Purpose of Study

The purpose of this study was to identify and test key elements of Rogers' Diffusion of Innovation theory that play a role in the adoption of pharmacogenomic testing into the oncology practice by assessing oncology nurses knowledge, attitudes, and support for use of pharmacogenomic testing.

Significance of the Study

Scientific knowledge of genomics has exponentially increased in the first decade of the 21st century. The growing applicability of genomic testing raises concerns surrounding the expanding knowledge deficit as well as multiple ethical concerns related to genomic testing. Genomic information has the potential to have a profound effect on our attitudes regarding the equal distribution of healthcare in our society (Cappelen, Norheim, & Tungodden, 2008). Nurses need to understand genomic information and implications for practice in order to permit incorporation of genomics into nursing care, enhance an attitude of approval towards genomics, provide more holistic care, and advocate better for their patients (Prows, 2011; Williams, Skirton, & Masny, 2006). The American Nursing Association (ANA) and the Institute of Medicine (IOM) have both identified the need for nurses who are prepared to take part in genomic health care services. However, inconsistent training and education in genomics continues to permeate nursing and other health care fields (Challen et al., 2005; Cragun, Couch, Prows, Warren, & Christianson, 2005; Forbes & Hickey, 2009).

Furthermore, pharmacogenomic testing, a specific type of genomic testing, is becoming more prominent in clinical practice. Currently there are 104 Food and Drug Administration (FDA)-approved drugs with pharmacogenomic information in their labels (U.S. Food and Drug Administration, 2012). Out of these FDA-approved drugs, 28 of them are directly related to oncology. Nurses are at the forefront of patient care, which makes them perfectly positioned to educate patients about new and innovative technologies associated with their health care. Therefore, nurses could play a critical role in the incorporation of pharmacogenomic testing and genotype-guided therapy into routine practice, especially with oncology patients.

There is growing evidence that a substantial contributor to cancer drug therapy is the patient's own genomic makeup (Prows, 2011). As noted previously, a multitude of pharmacogenomic tests are used in a variety of oncology settings for many different forms of cancers. Therefore, oncology nurses must become well-informed about pharmacogenomic testing in order to accurately administer cancer drugs and monitor the patient's response. Nurses need to be aware that both genomic and non-genomic factors contribute to side effects and toxicity. Moreover, nurses need to integrate this information into the teaching they do with patients and families. Additionally, they need to encourage patients and their families to watch for and report side effects and early signs of toxicity. Also oncology nurses need to be aware that additional pharmacogenomic testing may be necessary based on the specificity of this type of genomic testing. Pharmacogenomic testing only tests for specific gene variants. Therefore as technology expands and testing becomes available for additional gene variants, patients may benefit from additional pharmacogenomic testing.

Nurses, especially oncology nurses, have an important role in making sure that patients and families are informed about the purpose and limitations of pharmacogenomic testing. However, to do this, nurses must be accepting of, and knowledgeable about this type of genomic testing and therapy. Nurses who are knowledgeable about this type of testing and therapy will be able to become advocate and discuss the benefits and limitations of this therapy with patients and their families. Consequently, studies like this which provide an assessment of oncology nurses' knowledge, attitude, and support for use of pharmacogenomic testing will provide a baseline for deficits in knowledge and ethical concerns regarding pharmacogenomic testing among this population.

Summary

Pharmacogenomic testing is a relevant topic within the oncology setting and has a significant impact on the nursing care provided to these patients and their families. Rogers' Diffusion of Innovation theory was the conceptual framework that provided a basis for assessing variables that are related to the adoption of pharmacogenomic testing within the oncology field. It is often the individual's attitude that determines the rate of diffusion once the new knowledge is available. Therefore, this study and other research examining key elements that may affect the adoption of pharmacogenomic testing by oncology nurses will provide valuable insights that can be used in the development of interventions designed to facilitate the widespread adoption of pharmacogenomic testing in clinical practice.

Chapter II

Literature Review

Conceptual Framework: Diffusion of Innovation

The adoption of a new idea is often times very difficult despite many obvious advantages that this new idea may provide (Rogers, 2003). According to Rogers (2003), often many years pass before an innovation is widely adopted. An innovation is defined as an idea, practice, or object that is perceived as new by an individual (Rogers, 2003). Despite the fact that the word 'pharmacogenomics' was coined in 1959 by Friedrich Vogel of Heidelberg, Germany, widespread adoption of this new idea is still forthcoming (Motulsky & Qi, 2006). Nurses are among several disciplines that are now being introduced to pharmacogenomic testing as a new innovation.

Adoption of an innovation is a time-consuming process due to the fact that diffusion of the innovation must take place through the appropriate channels within the social system (Rogers, 2003). This process can be extensive at times, which makes this process difficult. Diffusion is the passive spread by which an innovation is communicated through certain channels within the social system over time (Rogers, 2003). Whereas dissemination is the active process that increases the awareness and adoption. According to Rogers (2003), mass media channels are more effective in generating knowledge about the innovation, whereas interpersonal channels are more effective in establishing and altering attitudes towards a new idea.

Finally, implementation is the planned efforts to put the idea into clinical practice (Greenhalgh, Robert, Macfarlane, Bate, & Kyriakidou, 2004). The elements of the diffusion of innovation process are shown in Figure 1. This framework was utilized to describe the process by which the idea of pharmacogenomic testing is diffused through the field of nursing. The characteristics of the innovation, as perceived by the individuals, determine the rate of adoption.

Additionally, an individual's innovativeness also is a determinant of the time it takes to adopt an innovation. Innovativeness is the degree to which an individual adopts new ideas as compared to other members of their social system. There are five adopter categories based on their innovativeness: innovators, early adopters, early majority, late majority, and laggards. Innovators are adventurous types that enjoy being on the cutting edge and like trying new ideas. The decision made by this type of individual within the implementation and confirmation stage is important to the subsequent decisions of other potential adopters. Early adopters use the innovator's decision to make their own adoption decisions. If the early adopters perceive that the innovation has been beneficial for the innovators, then they will adopt as well. This group is well respected for its well-informed decision-making. Therefore this group is where most opinion leaders in a social system reside (Rogers, 2003). The majority of the rest of the social system trust the decisions made by opinion leaders in order to be similar to others. Once these opinion leaders adopt the innovation the rate of adoption rapidly increases and a large section of the social system follows, which are called the early majority and then subsequently the late majority joins. Finally the last adopters are called the laggards and

they are considered very traditionalists or may be isolated from the rest of the social system, which decreases their rate of adoption of the innovation.

Multiple studies have revealed that there are typically the same percentage of individuals distributed within each innovativeness category for all social systems. This distribution should follow a bell-shaped curve and is utilized to assess whether a particular social system, such as oncology nursing, will have successful adoption of an innovation (Rogers, 2003)

This research study focused on the first three stages of the Diffusion of Innovation theory, as shown in Figure 2. It is important to understand what variables affect the development of knowledge and attitudes that may enhance the successful adoption of the innovation. Information concerning ways to speed up the rate of diffusion, dissemination, and implementation of the innovation will lead to a more successful widespread uptake of this innovation.

The first step focused on is initial awareness of the innovation. According to Rogers (2003), there are several characteristics that affect how one receives new knowledge such as prior experience, perceived need of the innovation, general attitude towards change, ruralality, and the work environment of the individual. This knowledge of the innovation then stimulates the individual to expand upon the information surrounding this topic. However, awareness of the innovation does not automatically lead to the decision to adopt this idea. The individual must then be persuaded to accept the innovation.

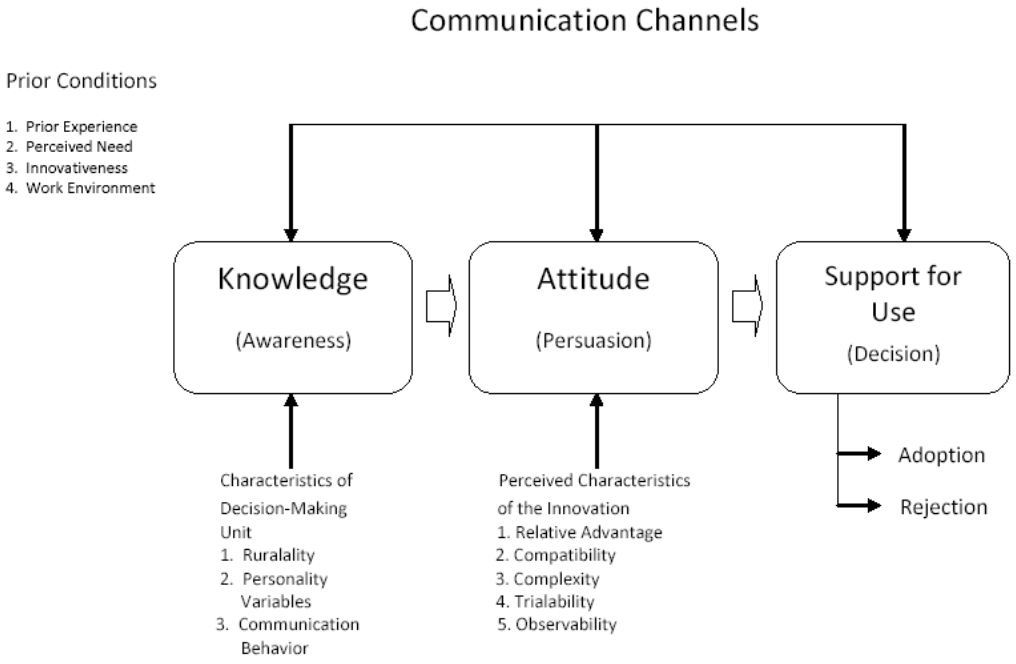


Figure 2: Modified Version of Rogers' Diffusion of Innovation as adapted by Dodson. This figure represents the stages of Rogers' Diffusion of Innovation used in this study.

The persuasion step relies on the attitude of the individual concerning the innovation (Rogers, 2003). Antecedents that affect the persuasion of an individual include relative advantage, complexity, compatibility, trialability, and observability. Relative advantage is the perception that the innovation is better than the current treatment. Compatibility is the degree to which the innovation coexists with the individual's existing values, past experiences, and needs. Complexity of the innovation is the degree of difficulty to comprehend. Trialability is the ability of the innovation to be incorporated into practice on a trial basis. Finally, observability is the degree to which the innovation is visible to the individuals. These characteristics influence the individual's attitude towards the innovation (Rogers, 2003). Once a decision has been made to adopt it, the innovation is implemented and finally confirmation of the innovation is obtained.

Concepts

The review of the literature conducted for this study focused on two main concepts within the field of nursing: knowledge of pharmacogenomic testing and attitudes concerning pharmacogenomic testing. Also a review of the literature surrounding support for use of pharmacogenomic testing and Rogers' Diffusion of Innovation model was conducted to identify key variables that may play a role in the process of diffusion of the innovation.

Knowledge of pharmacogenomic testing. Adequate competence in genomics as it relates to a nurse's specialized field supports the delivery of safe, quality care (Kirk, Calzone, Arimori, & Tonkin, 2011). A panel of leaders from almost 50 organizations created a document that entails the critical nursing competencies for genomics entitled "Essential Nursing Competencies and Curricula Guidelines for Genomics and Genomics" (Prows, 2011). This document describes the minimal genomic competencies for all registered nurses regardless of their practice setting or academic preparation. One main competency that all nurses should possess is the ability to provide patients with accurate and appropriate information regarding genomic information, resources, and/or services that allows for better decision-making skills. This competency allows the nurse to become a better patient advocate because nurses, who are knowledgeable about genomics, and more specifically pharmacogenomic testing, are better able to discuss the benefits and limitations of pharmacogenomic testing (Prows & Beery, 2008). In addition, nurses must be able to adequately assess their patient's knowledge of pharmacogenomic testing; therefore nurses must have an adequate knowledge of pharmacogenomic testing so they can assess whether their patient has adequate knowledge or if clarification is

necessary (Prows & Saldana, 2009). According to Prows and Saldana (p. 184, 2009), nurses need to know the following key points about pharmacogenomic (PG) testing:

> "(a) drug response is influenced by many different factors and bodily processes; (b) genomic test results provide a component of the necessary information when prescribers select and dose medications; (c) commercially available PG tests are not relevant for all medications; (d) genomic test results may be relevant to a patient's future health care because inherited genes, for the most part, do not change; (e) a patient's genomic test result may be relevant to biologic family members because they share inherited genes; and (f) depending on the type of analysis performed in the laboratory, a negative or normal test result may be a false negative if all possible variants associated with altered gene function were not analyzed."

While staff nurses are not responsible for ordering pharmacogenomic tests; however, as a patient advocate, it is within all nurses' scope of practice to be an active participant in their patient's care, which may include reminding prescribers that pharmacogenomic tests are available and should be considered. Additionally, as pharmacogenomic testing becomes more widespread, all nurses will become accountable for applying genomic information when administering medications that are based on a genomic test. Therefore, safe and optimal patient care will demand accurate and up-to-date knowledge of genomic and pharmacogenomic testing by nurses in practice, research, and education (Read, 2002). Furthermore, Beery and Hern (2004) stated that most practicing advanced practice registered nurses (APRNs) are inadequately prepared to integrate genomic concepts and pharmacogenomics into their practice. Due to this lack

of knowledge, in 2010, the Health Resources and Services Administration (HRSA) Expert Panel on Genomics and Nursing recommended that genomics is no longer an option but must be a part of nursing curriculum and continuing education programs (Beery & Hern, 2004).

Findings from a recent study of genetic/genomic competencies and nursing regulation in 10 countries (Kirk et al., 2011) revealed that only one of the countries included competencies in genomics and genomics in their regulatory standards for nursing and this was only at a "basic level". Kirk and colleagues argued that professional regulation of genomic/genomic competencies must be demonstrated in order for practicing nurses to gain the adequate knowledge base to provide safe and optimal care for their patients. According to Prows and Beery (2008), the minimum genomic competencies for nurses will be to learn about basic genomic information, which will give a good introduction for the explanation and acceptance of pharmacogenomic testing among clinicians.

Awareness of the knowledge and attitudes of genomic testing in general is pertinent to this study because it plays a large role in the knowledge and attitudes towards pharmacogenomic testing. A literature search of general knowledge towards genomic testing revealed a concerning knowledge deficit among the general public. Henneman, Timmermans, and Van Der Wal (2006) conducted a study to assess the knowledge, experiences, and future expectations of genomic testing in the Dutch population. Over half of the participants believed that they had a lower level of genomic knowledge compared to other Europeans and Americans. Also 79% of the participants did not know that they were genomically related to their siblings. In addition, knowledge of genomic

testing among healthcare professionals is deficient as well (Baars, Henneman, & Ten Kate, 2005; Dodson & Lewallen, 2011; Fargher et al., 2007; Hoop et al., 2010; Kadafour, Haugh, Posin, Kayser, & Shin, 2009). Dodson & Lewallen (2011) found that 76% of nursing students perceived their knowledge as minimal. Also Kadafour et al. (2009) found that 66% of healthcare professionals felt they had a general lack of knowledge. These findings should in theory correlate with pharmacogenomic testing knowledge.

After an extensive review of the literature, only nine research articles were located that reported findings from studies in which knowledge of pharmacogenomic testing among clinicians were assessed. The majority of these studies revealed that clinicians felt that they had limited knowledge of pharmacogenomic testing (Dodson & Lewallen, 2011; Fargher et al., 2007; Hoop et al., 2010; Kadafour et al., 2009; Roederer et al., 2012; Tamaoki et al., 2007; Stanek et al., 2012; Van Riper et al., 2012). However, findings from a case study in which 4 pharmacists were interviewed revealed that these participants believed that pharmacists are well informed about pharmacogenomic testing (El-Ibiary et al., 2008).

Furthermore, in a study that included nurses, pharmacists, physicians, and healthcare students, the group with the lowest total mean score (2.5 out of 5) for the questions designed to assess knowledge of pharmacogenomic testing were practicing nurses (Van Riper et al., 2012). Additionally, two studies had conflicting findings regarding the knowledge level of healthcare students. While findings from both studies (Dodson & Lewallen, 2011; Van Riper et al., 2012) indicated that healthcare students had higher perceived knowledge of genomics than practicing nurses, they disagreed about perceived knowledge of pharmacogenomic testing among healthcare students. Findings

from the study conducted by Dodson and Lewallen revealed that 76% of nursing students in an undergraduate program reported minimal to no knowledge of pharmacogenomic testing. In contrast, findings from the study by Van Riper et al. (2012) revealed that most healthcare students, including residents, pharmacy, and nursing students rated their knowledge of pharmacogenomic testing as excellent to very good. In addition, healthcare students scored the highest on the knowledge based questions regarding pharmacogenomic testing with a mean score of 3.25 out of 5.

In a study by Hoop et al. (2010), clinicians who had pharmacogenomic testing available at their worksite had a significantly higher median knowledge score of pharmacogenomic testing ($p = 0.03$), as did those who used it ($p= 0.009$). However, this study also revealed that 66% of all clinicians felt that they had a general lack of knowledge about pharmacogenomic testing. This finding coincides with the results found throughout the majority of the literature review, which revealed that clinicians generally underestimate their knowledge. Therefore, a perceived lack of knowledge concerning pharmacogenomic testing permeates this field, which reveals the need to test the actual knowledge of pharmacogenomic testing to gather accurate results regarding pharmacogenomic knowledge of clinicians.

Overall, there seems to be a pattern of a perception of a general lack of knowledge among all disciplines. Only two studies utilized methods to obtain both perceived and actual knowledge of pharmacogenomic testing among clinicians (Kadafour et al., 2009; Van Riper et al., 2012). Additionally, only four studies assessed the knowledge of nurses (Dodson & Lewallen, 2011; Fargher et al., 2007; Kadafour et al., 2009;Van Riper et al., 2012). These findings coincide with the conclusions found throughout other disciplines.

Furthermore, only one nursing study focused on the field of oncology and only included APRNs (Van Riper et al., 2012). Van Riper et al. (2012) study revealed that it is imperative that nurses understand the difference between genomic tests that assess risk of disease versus tests that are used as a tool for the guidance of treatment related to tumor markers and medication decisions. Therefore, this study looked at perceived and actual knowledge of different types of practicing nurses concerning pharmacogenomic testing specifically within the oncology field.

Attitudes concerning pharmacogenomic testing. Pharmacogenomic testing has the capability to affect major decisions for individuals and their families. Therefore, all genomic testing must be utilized in a just and confidential manner. According to Pestka (2003), nurses need to be especially aware of all factors involved with both testing and not testing, limitations of legal safeguards, family genograms that may reveal unsuspected information, cultural issues, and maintaining strict confidentiality. Beery and Hern (2004) revealed that clinicians need to have the skills necessary to apply the appropriate ethical, social, cultural, and personal values based on genomic technology. The understanding of healthcare professional attitudes towards genomic technology will lead to a better comprehension of these necessary skills.

Attitude is defined as "a favorable or unfavorable evaluative reaction toward something or someone exhibited in ones beliefs, feelings, or intended behavior" (Myers, 2009, p. 36). A person's attitude is often defined by social norms and helps organize their actions and provide a more predictable behavior. Typically an attitude is formed from the experiences one encounters. Three basic components comprise an attitude: emotional, informational, and behavioral. The emotional component involves one's

feelings or perception toward the concepts whether it is positive, negative, or neutral. The informational component consists of the beliefs and information one has concerning the particular concept. Finally, the behavioral component consists of the tendency to conduct oneself in a particular way toward the concept.

Clinicians must understand the psychological impact and implications for family members due to the ethical, legal and social issues associated with all genomic testing (Arnett, Claas, & Lynch, 2009). Attitudes towards genomic testing in general will play a large part in the formation of one's attitude towards pharmacogenomic testing. There has been a wide variety of research conducted on public attitudes concerning medical genomics. Both positive and negative attitudes have been identified. There are a few negative attitudes among the general public that have been consistent within the review of the literature. Overall, the main concern with genomic testing was the possibility of discrimination from either employment or insurance (Bates, Lynch, Bevan, & Condit, 2005; Haga et al., 2012; Henneman et al., 2006; Hietala et al., 1995; Jallinoja et al., 1998). Additionally a literature search revealed that clinicians also felt that genomic testing could potentially increase risk of discrimination by employment and insurance as well as fear of increased risk of breach of privacy (Freedman et al., 2003; Lawrence & Appelbaum, 2011).

Haga and Burke (2008) revealed that ethical issues related to pharmacogenomic testing were very similar to those associated with genomic testing such as the utilization of informed consent, timing of pharmacogenomic testing, and storage and retrieval of such testing, which seem to coincide with the general attitudes toward genomic testing in general. Additionally, eight articles revealed that attitudes of clinicians concerning

pharmacogenomic testing concurred with the previous findings related to genomic testing in general due to the fact that clinicians felt that pharmacogenomic testing would lead to discrimination based on one's genomic tests (Egalite et al., 2007; Hedgecoe, 2006; Hoop et al., 2010; Rogausch et al., 2006;Van Riper et al., 2012; Zgheib, Arawi, Mahfouz, & Sabra, 2011). Employment discrimination, insurance discrimination and racism were the terms frequently utilized in the qualitative studies. Furthermore, Avard et al. (2009) and Egalite et al. (2007) had a distinctive theme of fear of racial profiling and stigmatization based on pharmacogenomic testing, though it tends to relate to the overall fear of discrimination.

Another common attitude towards pharmacogenomic testing among clinicians was the concern of lack of privacy (Avard et al., 2009; Hedgecoe, 2006; Hoop et al., 2010; Tamaoki et al., 2007;Van Riper et al., 2012). One study, which was conducted in 2004 with clinicians, researchers, and leaders of drug companies and regulatory agencies, revealed that 40% of the sample feared that pharmacogenomic testing would lead to leakage of genomic information (Tamaoki et al., 2007).

Additionally, four of the articles revealed that clinicians believed that an informed consent was necessary for this type of procedure, despite the fact that a routine laboratory test does not require an informed consent (Avard et al., 2009; Hedgecoe, 2006; Hoop et al., 2010; Rogausch et al., 2006). Over 85% of physicians felt that informed consent was necessary for this type of testing (Rogausch et al., 2006). Another ethical concern of equal access to pharmacogenomic testing was revealed in two studies (Avard et al., 2009; Fargher et al., 2007). Another common theme prevalent in Hedgecoe's (2006) study that

coincides with the concern for equal access is the increased expense of this type of testing.

A common perceived advantage of pharmacogenomic testing was a reduction in adverse drug reactions (Avard et al., 2009; El-Ibiary et al., 2008; Rogausch et al., 2006; Tamaoki et al., 2007; Van Riper et al., 2012). Rogausch et al. (2006) revealed approximately 52% of physicians felt that pharmacogenomic testing had clinical utility and 54% felt that this would aid in the correct dosage of drugs, which would ultimately lead to a reduction in adverse drug reactions. Avard et al. (2009) and El-Ibiary et al. (2008) agreed with the findings by Rogausch et al. (2006) in that researchers felt that there were several advantages of pharmacogenomic testing, including better reliability of tests in order to reduce adverse drug reactions. However Kadafour et al. (2009) revealed a discrepancy among anticoagulation providers' perceptions regarding pharmacogenomic testing in that they were undecided about whether this testing will be more accurate or even decrease adverse drug reactions.

Furthermore, four studies revealed that pharmacogenomic testing would lead to overall better outcomes for patients (Egalite et al., 2007; Fargher et al., 2007; Roderer et al., 2012;Van Riper et al., 2012). Fargher et al. (2007) and Payne et al. (2011) revealed that clinicians felt that pharmacogenomic testing would increase confidence in personalized medication dosage and prescription. Additionally, Van Riper et al. (2012) agreed that pharmacogenomic testing will be overall beneficial to the patient because clinicians felt that pharmacogenomic testing would decrease the time it took to find the optimal dose for Warfarin (Van Riper et al., 2012).

Overall, there are many ethical concerns related to pharmacogenomic testing. However, there are some positive aspects of pharmacogenomic testing according to these clinicians. The majority of the ethical concerns were related to lack of privacy, need for informed consent, cost, and fear of discrimination (Avard et al., 2009; Egalite et al., 2007; Hedgecoe, 2006; Rogausch et al., 2006; Tamaoki et al., 2007;Van Riper et al., 2012). The positive aspects of pharmacogenomic testing acknowledged by clinicians were a reduction in adverse drug reactions and better clinical outcomes (Avard et al., 2009; Egalite et al., 2007; Fargher et al., 2007; Hoop et al., 2010; Mrazek et al., 2007; Rogausch et al., 2006; Tamaoki et al., 2007; Van Riper et al., 2012). Lee, Ma, and Kuo (2010) also revealed that patient and clinicians must overcome ethical barriers such as fear of loss of privacy, genomic profiling, and stigmatization. In addition, social issues such as the creation of health disparity should be focused upon due to many concerns related to this issue. Finally, economic issues such as the cost effectiveness of certain tests should be addressed for all clinicians (Lee et al., 2010). Many studies have been conducted on the attitude to pharmacogenomic testing in general, however, no studies have assessed the attitude of pharmacogenomic testing specifically related to oncology. Therefore, the current study assessed not only attitudes towards pharmacogenomic testing in general, but also attitudes specifically related to pharmacogenomic testing in the oncology field.

Support for use of pharmacogenomic testing. Integration of pharmacogenomic testing into routine practice ultimately depends upon clinicians' approval of, and query for, pharmacogenomic testing (Rogausch et al., 2006). For this study, support for use of pharmacogenomic testing was used to delineate the concept of adoption within Rogers'

Innovation of Diffusion theory. This concept is defined as degree to which the respondent uses pharmacogenomic testing information in their practice. In addition, support for use of pharmacogenomic testing was measured by the availability of pharmacogenomic testing within the healthcare field.

One of most significant reasons for the utilization of pharmacogenomic testing is the reduction in adverse drug reactions. Adverse drug reactions are the leading cause of hospitalization and are considered the fourth leading cause of in-patient death (Kongkaew, Noyce, & Ashcroft, 2008). An estimated 1 out of every 7 in-patient hospitalizations are exposed to an adverse drug reaction every year (Davies et al., 2009). In addition, Lazarou, Pomeranz, and Corey (1998) conducted a meta-analysis of prospective studies related to serious and fatal adverse drug reactions and revealed that on average two million hospitalized patients suffer from an adverse drug reaction even when the medications are prescribed correctly. These reactions can be dramatically decreased when dosage of medication is based on one's genomic profile (Amur et al., 2010; Vora et al., 2011). Therefore, nurses must recognize the opportunities available due to pharmacogenomic testing to develop successful strategies to best utilize genomic information into their practice because individualized care is optimal (Beery & Hern, 2004).

Diffusion of innovation. According to Rogers (2003), several variables potentially influence the adoption of an innovation. Certain variables such as prior experience, perceived need of the adopters, innovativeness, norms of society, demographic variables, personality variables such as age and education, and communication behavior are antecedents to the knowledge stage within this decision-

making process to adopt or reject an innovation. In addition, perceived characteristics of the innovation which include relative advantage, compatibility, complexity, trialability, and observability also play a significant role in the decision-making process.

Prior experience. Earlier information revealed that before any innovation can be adopted, an individual must be made aware of the innovation (Zaltman, Duncan, & Holbek, 1973). Previous innovation experience of the adopter can affect resistance to adopt the innovation. Ram (1987) revealed that past experience can bias one's decision-making process and is often called a 'mind set.' This mind-set plays an important role in shaping the adopter's perception and attitude formation. Therefore a positive previous innovative experience will increase the adoption of the innovation.

Perceived need of innovation. According to Ram (1987), unless an adopter perceives the need for the innovation, one is unlikely to adopt. Therefore the perceived need must occur before the innovation will be adopted.

Innovativeness. According to Rogers (2003), innovativeness is the degree to which an individual will adopt an innovation as compared to other members in their society. Therefore an individual's innovativeness influences their rate of adoption of an innovation.

Norms of society (Work environment). Rogers (2003) defined the norms of a society as the behavioral patterns of its members. Therefore, behavioral patterns will be specific to the work environment of the particular society. According to Jenkins (1999), no relationship was found between work environment including type of workplace, length of time within specific work environment, hours worked and the adoption of innovation.

Ruralality. Rogers (2003) revealed that adoption of innovation is based upon availability of resources, which was confirmed by a study conducted by Tawari and Davies (2009). However, Jenkins (1999) found no relationship with availability of resources and adoption of an innovation.

Personality variables. Personality variables are characteristics of the particular individual. Two personality variables, age and educational level, were assessed in prior research about diffusion of innovations. Based on the 4000 diffusion publications that Rogers reviewed, inconsistent evidence was found on whether age influenced the adoption of new ideas (Rogers, 2003). Almost half of the studies showed no relationship, whereas a few studies showed conflicting results in that some studies revealed younger individuals as early adopters whereas other studies showed that older individuals were the early adopters. Based on the current literature review, no studies have revealed a relationship between age and adoption of an innovation (Damanpour & Schneider, 2009; Ostergaard, Timmermans, & Kristinsson, 2011; Tawari & Davies, 2009). Moreover, according to Rogers, many studies reported a relationship between adoption of innovation and more years of formal education. Recent studies also coincide with Rogers (2003). These studies found that more formal education had a positive correlation with adoption of innovation (Damanpour & Schneider, 2009; Ostergaard et al., 2011; Tawari & Davies, 2009).

For the current study, the variables that were assessed were age, years of experience in the oncology setting, education level, certification in oncology, currently practicing in oncology field, time since last genomic and pharmacogenomic education,

association with a pharmacogenomic testing research site and perceived genomic and pharmacogenomic testing knowledge.

Communication behavior. According to Rogers (2003), mass media channels are more effective in generating knowledge about the innovation, whereas interpersonal channels are more effective in establishing and altering attitudes towards a new idea.

Relative advantage. The relative advantage of an innovation may be in the form of economic gain or beneficial to society in some other form. The costs that are saved could be either financial or social, such as exclusion from peer groups (Ram, 1987). The innovation could also improve performance or provide a better solution to a problem. According to Rogers (2003), if an innovation has a low relative advantage, adoption will be resisted among the potential adopters.

Compatibility. Compatibility characterizes the consistency with the existing values of the adopter, as well as traditional and cultural values of the society. This variable is also linked to the concept of pervasiveness. Pervasiveness of an innovation is the amount to which it necessitates change in behavior of the potential adopter (Ram, 1987). Therefore, the higher the degree of pervasiveness equals more behavioral change, which leads to resistance to adoption.

Complexity. The complexity of an innovation is comprised of how easy it is to understand the innovation as well as how easy it is to implement (Ram, 1987). Two separate components play a role in comprising the complexity of the innovation. Therefore, the easier to understand and implement the innovation, creates less resistance to adoption.

Trialability. Trialability of an innovation relates to the ability of the innovation to be trialed before adoption as well as the ability to trial the innovation in stages (Roger, 2003). According to Ram (1987), the less trialability equals more resistance to adoption of the innovation.

Observability. According to Rogers (2003), the rate of adoption increases as the innovation becomes more visible to the potential adopters. Observability was categorized as having available pharmacogenomic tests or not.

Summary

Additional education about, and the acceptance of pharmacogenomic testing will most likely be required before genomically guided therapy can be widely utilized (Lanfear & McLeod, 2007). Nurses could play a critical role in the integration of pharmacogenomic testing and genotype-guided therapy into routine practice. However, to do this, nurses must be accepting of and knowledgeable about this type of genomic testing and therapy. Nurses who are knowledgeable about this type of testing and therapy will be able to discuss the benefits and limitations of this therapy with their patients. Nurses must make opportunities to advance their knowledge in genomics including pharmacogenomic testing, because nurses are in an excellent situation to synchronize inclusive care for their patients that includes these essential genomic components (Pestka, 2003).

In order to be a patient advocate, a nurse should have an adequate knowledge base about pharmacogenomic testing as well as accessible resources that may enhance the

patient's understanding of this therapy (Prows & Beery, 2008). Educating nurses about pharmacogenomic testing and genotype-guided therapy should ultimately have a huge impact on patient's understanding and acceptance of pharmacogenomic testing.

Chapter III

Methodology

The purpose of this study was to identify and test key elements of Rogers' Diffusion of Innovation theory that play a role in the adoption of pharmacogenomic testing into the oncology practice by assessing oncology nurses' knowledge, attitudes and support for use of pharmacogenomic testing. In this chapter, the research design, population and sample, instruments used to measure variables, the methods used to protect human subjects, and the procedures for conducting the study are described.

Research Design

Based on the information obtained from the review of literature, a study of the knowledge, attitudes, and support of use concerning pharmacogenomic testing in the oncology nursing field was pertinent. In order to assess this knowledge and attitudes, the type of design that was implemented was a cross-sectional, descriptive survey design. A cross-sectional design was chosen because it gathers information on a population at one point in time (Polit & Beck, 2008). In addition, the feasibility of this study allows for the use of this type of design.

Furthermore, within a descriptive survey design, the dependent variable(s) is measured and then compared within the group, while the independent variable(s) is observed as it naturally occurs in the population (Brink & Wood, 1998). Due to the fact that the independent variable is only observed rather than controlled, the independent variable is controlled through sample selection (Brink & Wood, 1998). Therefore, a

large, representative sample was utilized (Shadish, Cook, & Campbell, 2002). Moreover, a power analysis was conducted to control the possibility of failing to reject a false null hypothesis, (i.e. a Type II error), by guaranteeing power at least 0.8 (Brink & Wood, 1998). The statistical program, Statistics Calculator, was utilized to calculate the appropriate sample size for sufficient power (Soper, 2012). A f^2 was utilized to determine the appropriate minimum sample size required to test for significance, which is calculated by $R^2/ (1–R^2)$. A medium effect size for R^2 in the analysis of variance context is 0.06 (Green & Salkind, 2005). Therefore, the f^2 was set at 0.06. Using the significance level of 0.05, in order to detect a moderate effect size of 0.06, the minimum sample size was determined to be 202.

Setting and Sample

Population. The population addressed in this study were nurses who practice in the oncology setting within North Carolina. The sampling frame included all nurses in the state of North Carolina who identified themselves as a nurse with a background in oncology through the North Carolina Board of Nursing. The study of oncology nurses only in the state of North Carolina was chosen due to the feasibility of this study related to easier access to information as well as knowledge of specific medical facilities in the state of North Carolina associated with pharmacogenomic testing sites specifically related to Tamoxifen.

Eligibility criteria. The eligibility criteria for the sample were currently licensed practical nurses or registered nurses in an oncology setting within the state of North Carolina.

Data Sources and Collection

The sample was obtained from the North Carolina Board of Nursing. This organization has a list of all nurses that work in North Carolina in an oncology setting. A request form was submitted that included the type of media desired for the contact list (e.g., CD-ROM, Excel Spreadsheet), contact information for this investigator, a description of how the data would be used, and what data was being requested, such as all Registered Nurses (RN) in Wake, Durham and Orange counties (See Appendix A). For this study, a request was submitted for a list of all Licensed Practical Nurses (LPN) and RNs within the state of North Carolina who work in the oncology field. Around two thousand seven hundred nurses met the eligibility criteria. For each of these nurses, their mailing address was obtained along with additional data such as type of degree and setting of employment. An invitation to participate was distributed to these nurses via a postcard sent to their mailing address. The postcard had a link to an online survey through the survey engine, Survey Monkey, in order for this to be completed with anonymity. A chance to win an i-Pad was offered for those who completed the survey in order to provide an incentive for a good response rate.

Aims

Based on the literature review, the following research questions were formulated.

Aim #1

A. What is the perceived and actual knowledge of oncology nurses in the state of North Carolina about basic genomic and pharmacogenomic testing?

B. What attitudes do oncology nursing in the state of North Carolina have

concerning pharmacogenomic testing?

C. What is the support for use of pharmacogenomic testing in the oncology field throughout the state of North Carolina?

Aim #2

What are the relationships between actual knowledge of oncology nurses in the state of North Carolina concerning basic genomic and pharmacogenomic testing and the variables: prior experience with pharmacogenomic testing, innovativeness, perceived need of innovation, work setting, ruralality, communication behavior, and personality variables such as age, years of experience in the oncology setting, education level, certification in oncology, currently practicing in oncology field, time since last genomic and pharmacogenomic education, association with a pharmacogenomic testing research site and perceived genomic and pharmacogenomic testing knowledge?

Aim #3

What are the relationships between attitudes of oncology nurses in the state of North Carolina concerning pharmacogenomic testing and the variables: relative advantage, compatibility, complexity, trialability, and observability of the innovation, actual genomic and pharmacogenomic testing knowledge, prior experience with pharmacogenomic testing, innovativeness, perceived need of innovation, work setting, ruralality, communication behavior, and personality variables such as age, years of experience in the oncology setting, education level, certification in oncology, currently practicing in oncology field, time since last genomic and pharmacogenomic education, association with a pharmacogenomic

testing research site and perceived genomic and pharmacogenomic testing knowledge?

Aim #4

What are the relationships between the support for use of pharmacogenomic testing in the oncology field and the following variables: actual genomic and pharmacogenomic testing knowledge, overall attitudes towards pharmacogenomic testing, attitudes specifically related to Tamoxifen, age, years of experience in the oncology setting, education level, certification in oncology, currently practicing in oncology field, time since last genomic and pharmacogenomic education, association with a pharmacogenomic testing research site and perceived genomic and pharmacogenomic testing knowledge?

Measurement of Variables

Several concepts related to demographics were measured, including age, years of experience in the oncology setting, education level, certification in oncology, currently practicing in oncology field, time since last genomic and pharmacogenomic education, association with a pharmacogenomic testing research site, prior experience with pharmacogenomic testing, perceived need of innovation, innovativeness, work setting, ruralality, association with a pharmacogenomic testing research site. Additionally, other concepts that were assessed included basic genomic knowledge and pharmacogenomic knowledge as well as perceived knowledge of genomics and pharmacogenomic testing. Concepts related to favorability of the innovation such as relative advantage, compatibility, complexity, trialability, and observability were also measured. Finally, overall attitudes toward pharmacogenomic testing, and attitudes related specifically to

pharmacogenomic testing for Tamoxifen, as well as the concept of support for use of pharmacogenomic testing within the oncology field were assessed. These variables are highlighted in Table 1.

Knowledge is defined as the information gained through education or practice. Basic genetics is defined as the area of study related to heredity and the variation in inherited characteristics ("Genetics", 2011). Basic genetics knowledge was operationalized as the number of basic genetic questions correctly answered. Pharmacogenomic testing is defined as the study of the interaction of genomics and pharmacotherapy in which genomic testing is used to guide a patient's drug therapy (Foley & Quigley, 2010). Pharmacogenomic testing knowledge was operationalized as the number of pharmacogenomic testing questions answered correctly.

Table 1: Measurement of Concepts **Concepts**	**Operationalization**	**Measurement**
Prior Experience (Previous awareness of pharmacogenomic testing)	Whether or not the respondent has heard of the term pharmacogenomic testing prior to this survey and whether or not pharmacogenomic testing is available at their place of work	Question # 37 and #51
Perceived Need of Innovation (The respondent's feelings of whether this innovation will be of benefit)	Whether or not the individual feels that pharmacogenomic testing will be useful in the oncology setting	Question # 66
Innovativeness (The degree to which an individual adopts new ideas as compared to other members of their social system)	Whether the respondent is either an innovator, early adopter, early majority, late majority, or laggard	Innovativeness Scale
Work Environment (The behavioral patterns of the society)	Specific type of workplace for which one works	Questions # 11 and #37
Basic Genetic Knowledge (Information gained through education or practice related to genetics)	Number of basic genetic questions correctly answered	Questions # 41-45
Pharmacogenomic Testing Knowledge (Information gained through education or practice related to pharmacogenomics)	Number of pharmacogenomic testing question answered correctly	Questions # 46-50

Ruralality (The location of the respondent's workplace)	Either rural or urban place of employment.	Question # 9
Personality Variables (Individual characteristics of the respondent)	Age, educational background, years of experience in oncology, certification in oncology, currently practicing in oncology field, time since last genetic and pharmacogenomic education, and association with a pharmacogenomic testing site	Questions # 2, 3, 4, 5, 7, 10, and 33
Communication Behavior (The process by which an individual receives up-to-date information)	The mode of media/communication one receives information.	Question # 79
General Attitude (A favorable or unfavorable position about the innovation)	Whether the respondent believes that pharmacogenomic testing should be utilized in nursing care and number of favorable responses towards use of pharmacogenomic testing in general.	Questions # 56-59, and 62-64
Attitude about pharmacogenomic testing specifically related to oncology field (A favorable or unfavorable position about the innovation within the oncology field)	Number of favorable responses towards use of pharmacogenomic testing within the oncology field.	Questions # 66-71
Overall Attitude (A favorable or unfavorable position about the innovation including position specifically related to the oncology field)	Number of favorable responses towards use of pharmacogenomic testing in general and within the oncology field and whether the respondent believes that pharmacogenomic testing should be utilized in nursing care	Questions # 56-59, 62-64, 66-71
Relative Advantage (Perception that the innovation is better than the current treatment)	Whether pharmacogenomic testing is beneficial for the field of oncology.	Question # 66
Compatibility (The degree to which the innovation coexists with the individual's existing values, past experiences, and needs)	Whether the respondent believes that nurses should incorporate pharmacogenomic testing into their practice	Question # 56
Complexity (The degree of difficulty to comprehend)	Whether the respondents believe that pharmacogenomic testing is hard to understand.	Question # 60
Trialability (The ability of the innovation to be incorporated into practice on a trial basis)	Whether the respondent believes that pharmacogenomic testing can be adjusted.	Question # 61
Observability (The degree to which the innovation is visible to the individuals)	Whether or not the individual uses or observes pharmacogenomic testing in their place of work.	Question # 37, 38, 39, 40, and 53
Support for Use (The degree to which pharmacogenomic testing is utilized)	Degree to which the respondent uses pharmacogenomic testing information in their practice.	Question # 55

Antecedents to knowledge within Rogers' Innovation of Diffusion framework are prior experience, perceived need of innovation, innovativeness, work environment, ruralality, personality variables such as age and education level, and communication behavior. Prior experience is defined as the previous awareness of pharmacogenomic

testing. This concept was operationalized by whether or not the respondent had heard of the term pharmacogenomic testing prior to taking this survey and whether pharmacogenomic testing was available at their place of work. Perceived need of innovation was defined as the respondent's feelings of whether this innovation would be of benefit. This concept was operationalized by whether or not the individual felt that pharmacogenomic testing would be useful in the oncology setting. Innovativeness was defined as the degree to which an individual adopts new ideas as compared to other members of their social system. Innovativeness was operationalized by whether the respondent was an innovator, early adopter, early majority, late majority, or laggard, as evidenced by their score on the Innovativeness Scale. Norms of society or work environment were defined as the behavioral patterns of the society. This variable was operationalized by the specific type of workplace the nurse worked at (e.g. inpatient oncology unit, ambulatory care/outpatient center, hospice/palliative care, etc.). Ruralality was defined as the location of the respondent's workplace. This variable was operationalized as the respondent's response to working in either a rural or urban setting. Personality variables were measured as well (e.g. age, educational level, certification in oncology, currently practicing, etc.). Certification in oncology was defined as a nurse who is certified by a credentialing organization in the oncology field. This variable was operationalized by whether the nurse held one or more of the seven oncology nursing certifications as governed by the Oncology Nursing Certification Corporation. Association with a pharmacogenomic testing research site was defined as the affiliation with a facility that was a pharmacogenomic testing center. This variable was operationalized by whether the respondent worked at one of the facilities that has been a

part of the Tamoxifen pharmacogenomic testing study. Finally, communication behavior was defined as the process by which an individual receives up-to-date information. This concept was operationalized by the mode of media/communication one receives information.

Attitude was defined as a favorable or unfavorable position about the innovation. Overall attitude was operationalized by the number of favorable responses towards use of pharmacogenomic testing in general and whether the respondent believed that pharmacogenomic testing should be utilized in nursing care. Attitude specifically related to pharmacogenomic testing within the oncology field was operationalized by the number of favorable responses towards pharmacogenomic testing. In combination with attitude, the favorability of the innovation was measured by assessing relative advantage, compatibility, complexity, trialability, and observability. Relative advantage was the perception that the innovation was better than the current treatment. This concept was operationalized by whether the respondent believed pharmacogenomic testing was beneficial for the field of oncology. Compatibility was the degree to which the innovation coexists with the individual's existing values, past experiences, and needs. Compatibility was operationalized by whether the respondent believed that nurses should incorporate pharmacogenomic testing into their practice. Complexity of the innovation was defined as is the degree of difficulty to comprehend. This concept was operationalized by whether the respondents believed that pharmacogenomic testing was hard to understand. Trialability is the ability of the innovation to be incorporated into practice on a trial basis. This concept was operationalized by whether the respondent believed that pharmacogenomic testing could be adjusted to work better for their type of

work setting. Finally, observability was defined as the degree to which the innovation was visible to the individuals. This concept was operationalized by whether or not the individual used or observed pharmacogenomic testing in their place of work. Finally, support for use of pharmacogenomic testing was defined as the degree to which pharmacogenomic testing was utilized. This concept was operationalized by the degree to which the respondent used pharmacogenomic testing information in their practice.

Instruments

Knowledge, Attitude, and Support for Use Questionnaire-Pharmacogenomic Testing (KAQ-PGx). The measure that was utilized to assess these concepts was a modified version of Van Riper et al.'s (2012) Knowledge and Attitude Questionnaire about Pharmacogenomic testing (KAQ-PGx). The original questionnaire was developed by a team of experts from the University of North Carolina (UNC) Center for Genomics and Society and the UNC Institute of Pharmacogenomics and Individualized Therapy (Roederer et al, 2012). This questionnaire assesses knowledge concerning pharmacogenomic testing as well as addressing areas of concern that were expressed throughout existing literature. The questionnaire was evaluated by an interdisciplinary group, including nurses, physicians, and pharmacists, who were knowledgeable about pharmacogenomic testing. Then a pilot study was conducted by testing five clinicians prior to data collection. The original survey was comprised of: six background information questions, two questions concerning overall perceptions of knowledge regarding genomics and pharmacogenomic testing, ten basic knowledge questions (five about genomics and five about pharmacogenomics), eight questions concerning attitudes about pharmacogenomic testing (four about pharmacogenomic testing in general and four

focusing on pharmacogenomic testing to guide warfarin therapy), four questions for clinicians with prescriptive privileges, and two questions to assess interest in future continuing education courses regarding pharmacogenomic testing. The University of North Carolina at Chapel Hill Office of Human Research Ethics determined that the Institutional Review Board approval was not mandatory because responses to the questionnaire were anonymous (Roederer et al., 2012).

A team of experts on pharmacogenomic testing knowledge and nursing care evaluated and modified the revised version to establish content validity. The modified version included nine additional demographic questions that specifically relate to oncology nurses. Also five questions were added to the background of genomics/pharmacogenomics section that specifically relate to nursing. Additionally, a brief summary of pharmacogenomic testing was included within the survey. Moreover, a question regarding their communication behavior was added to the final section. Finally, the section of attitudes regarding pharmacogenomic testing for Warfarin was deleted due to the fact that oncology medications replaced these items, which related more closely with oncology nursing.

Additionally, ten cognitive interviews were conducted with inpatient and outpatient oncology nurses in order to ascertain the validity of the 43 KAQ-PGx items and directions. A coding system was developed for each category for their responses. Based on these interviews, the following changes were made: 35 of the 43 items were interpreted as intended and were unchanged; 6 items were revised; 2 items were deleted; and 9 items were added. In addition, the informational paragraph within the questionnaire was revised.

Once the cognitive interviews were completed and modifications made, five oncology nurses pilot tested the questionnaire to determine the need for additional revisions and as well as to determine approximate length of time required for completion of questionnaire.

The finalized survey includes a total of 52 items: 11 demographic questions, two questions assessing background in genomic and pharmacogenomic testing education, two questions that assesses overall perceptions of understanding about genomics and pharmacogenomic testing, four questions designed to assess the availability and utilization of pharmacogenomic testing information in their place of work, five basic knowledge questions about genomics, five knowledge questions about pharmacogenomic testing, eight questions regarding overall attitudes about pharmacogenomic testing, six questions focused on attitudes related to pharmacogenomic testing used within the oncology field, five questions pertaining to prescriptive privileges, three questions about the clinicians' interest in future educational offerings about pharmacogenomic testing, and an open-ended question addressing any additional comments or concerns of the clinicians. In addition, an educational summary of pharmacogenomic testing was incorporated into the questionnaire (See Appendix B).

Innovativeness Scale (IS). As previously stated, innovativeness was defined as the degree to which an individual adopts new ideas as compared to other members within their society. The Innovativeness Scale developed by Hurt, Joseph, and Cook (1977) was utilized to measure innovativeness. This scale has construct validity due to the similarity between the outcomes and prior publication of Rogers' and Shoemaker's adopter category distribution (Hurt et al., 1977). Additionally, the scale had a Cronbach's alpha

of 0.94 (Hurt et al., 1977). Twenty questions comprise this survey that assesses how an individual responds to their environment. The score was calculated to determine which type of adopter the individual is categorized (e.g. Innovator, Early Majority, etc.).

Each individual's innovativeness score was calculated per the published guidelines (Hurt et al., 1977) (See Appendix C). In step 1, responses to questions 4, 6, 7, 10, 13, 15, 17, and 20 were summed together. Then step 2 consisted of summing together the responses from questions 1, 2, 3, 5, 8, 9, 11, 12, 14 16, 18, and 19. Finally, in the final step the following formula was used: 42 + total score from step 2 – total score from step 1 (Hurt et al., 1977). Each question utilized a five-point Likert scale with Strongly Disagree coded as 1 to Strongly Agree coded as 5. Each respondent was then classified as an Innovator, Early Adopter, Early Majority, Late Majority, or Traditionalists based on their scores, and coded 5, 4, 3, 2, and 1, respectively. Scores above 80 were classified as Innovators, scores between 69 and 80 were classified as Early Adopters, scores between 57 and 68 were Early Majority, scores between 46-56 were Late Majority, and scores below 46 were considered Traditionalists (Hurt et al., 1977).

Nursing Practice Questionnaire-Pharmacogenomic Testing (NPQ-PGx). The Nursing Practice Questionnaire was originally developed by Brett in 1987 to measure nurses' adoption of research findings. Rogers' Diffusion of Innovation framework was used to guide the development of this instrument. Content validity was established prior to pilot testing with a total of 25 graduate nursing students. The results established reliability of 0.82, with test-retest reliability of 0.83 (Brett, 1987).

The questionnaire included six questions that assess degree of adoption of an innovation. Four questions assess the knowledge phase, one measures the attitude phase,

and one assesses the support for use phase. If one answers positively to any of the first four questions they are at least within the knowledge phase. If the respondent answers positively to the fifth question, they have a positive attitude towards the innovation. Finally, the final questions assess whether they have never, sometimes, or always use the innovation, which measured their support for use of the innovation. This questionnaire was scored by assigning a one to a positive answer to having ever heard of the term pharmacogenomics, assigning a one to a positive answer to whether a nurse should use this in their nursing practice, and finally a zero was assigned to an answer that pharmacogenomic testing information was never used in their nursing care, a one if they sometimes use this, and a two if they always use this in their nursing care. Therefore, a maximum score of four could be achieved. Respondents with a score of 0 are in the unaware stage, a score of 1 are in the aware stage, 2 are in the persuasion stage, 3 or greater are in the adoption stage (Brett, 1987). This questionnaire was utilized to assess all three stages of Rogers' Diffusion of Innovation that is focused upon in this study.

Protection of Human Subjects

The study proposal and informed consents were submitted to the University of North Carolina at Chapel Hill Office of Human Research Ethics for review and approval before implementation of the study. All participants were asked to sign the informed consent and were assigned a number for confidentiality (See Appendix D). The on-line survey was available on Survey Monkey under a professional gold account. This account utilizes Secure Sockets Layer (SSL) encryption, which is a 128 bit encryption. This account sends encrypted links to research participants, in which the link and survey pages are secured by Verisign, and then submitted to a secured account. Additionally, the

collected data was downloaded over a secure channel. Furthermore, the respondents IP addresses were not stored in the survey results.

Statistical Analyses

Univariate statistics were conducted for all demographic variables, including ranges, means, medians, and standard deviations for continuous variables and frequencies and percents for categorical variables. To address part A of Aim #1, the total score for the basic genomic knowledge questions, the total score for the pharmacogenomic knowledge questions, and the combination of these total scores were calculated for each respondent. Also the total score for overall attitude, attitudes specifically related to Tamoxifen, and the total score for support for use of pharmacogenomic testing were calculated to address parts B and C of Aim #1. Finally, Cronbach's alpha was used to measure the internal consistency of these totals. In addition, summary statistics were calculated as well as the formation of box plots to assess results.

To address knowledge in Aim #2, a contingency table was generated for each knowledge item in the questionnaire and each of these categorical variables: age, prior experience with pharmacogenomic testing, innovativeness, perceived need of innovation, ruralality, communication behavior, educational level, certification in oncology, currently practicing in oncology field, association with a pharmacogenomic testing research site, and perceived genomic and pharmacogenomic testing knowledge. A Pearson's chi square test was utilized to determine whether the distribution of the categorical variables differ from one another. Therefore if contingency was found among the categorical variables, then they are not independent of one another. Furthermore, if no contingency was found among the categorical variables, then they are independent of one another and

there is not enough evidence to reject the null hypothesis. The null hypotheses to be considered were:

H_0: Age, prior experience with pharmacogenomic testing, years of experience in the oncology setting, innovativeness, perceived need of innovation, ruralality, communication behavior, educational level, certification in oncology, currently practicing in oncology field, work environment, association with a pharmacogenomic testing research site are independent of perceived genomic and of pharmacogenomic testing knowledge considering one variable at a time.

A one-way analysis of variance (ANOVA) was conducted relating the total number of correct responses on genomic knowledge, on pharmacogenomic testing knowledge and on the combination of these questions to each predictor variable: age, prior experience with pharmacogenomic testing, years of experience in the oncology setting, innovativeness, perceived need of innovation, ruralality, communication behavior, educational level, certification in oncology, currently practicing in oncology field, work environment, association with a pharmacogenomic testing research site, and perceived genomic and pharmacogenomic testing knowledge. A power analysis was conducted to determine the minimum required sample size to achieve statistical significance in order to perform the ANOVA, which can be found in the research design section. This statistical test determined whether the total score of a set of knowledge questions was significantly different within levels for each of the predictor variables. The null hypothesis tested was:

$H_{0:}$ No difference in the knowledge mean across the different levels of each

predictor variable.

Once the analyses were conducted, a post hoc analysis was conducted for all cases with a significant F value to determine which levels of the associated predictor were similar in mean knowledge and they were combined.

Finally, regression models were generated for the totals of the basic genomic knowledge questions, the pharmacogenomic testing knowledge questions, and the combination of these knowledge questions. The predictor variables were comprised of the variables identified from the one-way ANOVA. Only predictors that had a significant one-way ANOVA F test values set at a $p<0.05$ were utilized and coded as appropriately defined indicator variables. Multicollinearity was assessed prior to performing regression models to determine whether two or more predictor variables were highly correlated.

Variable selection methods were conducted to determine which combination of variables were jointly significant predictors of each outcome variable. Initially, a forward selection was conducted. The initial model included no variables and then each variable was chosen one by one and added to the model until no benefit was found with each additional variable added. Then a backward elimination was conducted. Finally, stepwise selection was conducted in which variables were added and removed from the model to obtain the best fit for each outcome variable. If different models were generated from the variable selection procedures, then the Akaike Information Criterion (AIC), Bayesian information criterion (BIC), and the predicted residual sum of squares (PRESS) were utilized to compare the alternative models and select the most appropriate model.

In addition to knowledge, respondents were asked thirteen questions regarding their attitudes regarding pharmacogenomic testing. Seven questions assessed the

respondents' attitude towards pharmacogenomic testing in general and six questions assessed their attitude towards pharmacogenomic testing specifically related to the oncology field. The answers to these questions were coded for positive attitudes or negative attitudes toward the specific topic. Six questions utilized a Likert scale and had a range from 1-4 with 4 being non-favorable. Additionally, seven questions utilized a yes/no response, in which were coded as 1 for favorable responses and 2 for non-favorable responses. Questions 69-71 were reverse coded so that larger values for all the questions corresponded to a more negative attitude. Therefore the higher the score, the more negative the attitude. The possible range for general attitude towards pharmacogenomic testing was 7-20 due to the fact that some questions utilized a Likert scale and others utilized a yes/no response. The possible range for attitude toward pharmacogenomic testing related to oncology was 6-18. Finally the possible range for overall attitude was 13-38.

The same kinds of statistical analyzes as conducted for Aim #2 were conducted for Aim #3 but using attitude variables as outcomes (that is, contingency table, one-way ANOVA, and regression analyses). Aim #3 null hypotheses included:

$H_{0:}$ No difference in the overall attitude or attitude specifically related to Tamoxifen mean score across the different levels of each variable.

H_0: The knowledge of the respondents is independent of the overall attitude about pharmacogenomic testing as well as the attitude specifically related to pharmacogenomic testing of Tamoxifen.

The same kinds of statistical analyzes as conducted for Aim #2 were conducted for Aim #4 but using support for use of pharmacogenomic testing variable as the outcome. The null hypotheses for Aim #4 were:

$H_{0:}$ No difference in the support for use mean score across the different levels of each variable.

H_0: The knowledge of the respondents is independent of the support for use of pharmacogenomic testing.

H_0: The overall attitude and attitude specifically related to Tamoxifen of the respondents is independent of the support for use of pharmacogenomic testing.

Finally, regression models were created for the overall attitude scores, attitudes specifically related to Tamoxifen, and support of use of pharmacogenomic testing.

The assumptions that underlie linear regression are that there are linear relationships between the dependent and independent variables, independence of errors in which there is no serial correlation, constant variance in errors, and a normal distribution of errors and so symmetrical without outliers. Residual analyses were conducted to assess whether results for generated models are reasonably considered to satisfy underlying assumptions. When this was the case, the residuals appeared to be random without asymmetry and outliers as well as with constant spread. Possible asymmetry was addressed with transformations. Outliers were addressed with sensitivity analyses to assess whether the presence of those outliers had an influence on conclusions or not. The statistical package, SAS 9.2 was used to perform all quantitative analyzes.

Summary

This chapter is a summary of the methodological approach that was utilized for this research study to test key elements of Rogers' Diffusion of Innovation theory in order to assess oncology nurses' knowledge, attitudes and support for use of pharmacogenomic testing.

The design of the study was a descriptive survey design to obtain information relevant to the concepts found within the literature. A postcard was mailed to the entire population provided by the North Carolina Board of Nursing. The postcard included a link to the online questionnaire. Data collection methods and statistical analyses were described.

Chapter IV

Results

This chapter reports the results from this study including a description of the findings and statistical analyses performed on the data.

Sample Demographics

The sample was obtained from the North Carolina Board of Nursing. The population included 2705 oncology nurses in which a total of 386 subjects started the online survey representing a 14.3% response rate. Out of the surveys that were started, 368 were used in this data analysis; the other 16 surveys were not used because more than half of the items were unanswered.

Demographic data was collected on all participants (see Table 2 which includes the total number of available responses for each variable). Each respondent was asked to provide their age, highest degree obtained, whether they have a certification in oncology, and if so, what type, whether they are currently practicing as an oncology nurse, length of time working in oncology, length of time since working in oncology, if not currently practicing, whether they work in a rural or urban setting, type of oncology setting, and communication behavior.

The majority of the respondents (31%) were between the ages of 50-59 years. In addition, almost 46% of the respondents had a Bachelor's degree as their highest degree obtained, followed by 26.6% with an Associate's degree. Over 37% of the participants

worked in an ambulatory or outpatient oncology setting and 36.8% worked in an inpatient oncology setting.

Over 90% of the participants are currently working as an oncology nurse and 47% of these have been working in oncology for over 20 years. Additionally, 55% of all the respondents have a certification in oncology, in which the Oncology Certified Nurse was the most commonly type of certification acquired. Furthermore, 76.9% of the nurses identified themselves as working in an urban setting.

Table 2: Demographic Variables	**n (%)**
Age (years)	
18-29	40 (10.9)
30-39	86 (23.4)
40-49	99 (26.9)
50-59	114 (31)
60-69	28 (7.6)
70 or greater	1 (0.3)
Total	**368**
Degree	
LPN	4 (1.1)
Diploma	25 (6.8)
AD	98 (26.6)
BSN	167 (45.4)
MSN	44 (12)
Nurse Practitioner	3 (0.8)
DNP	2 (0.5)
PhD	4 (1.1)
Total	**347**
Certification in Oncology	
Yes	202 (54.9)
Type	
OCN[a]	178 (88)
CPON[b]	0
CPHON[c]	1 (0.5)
AOCN[d]	8 (4)
CBCN[e]	4 (2)
AOCNP[f]	9 (4.5)
AOCNS[g]	2 (1)
No	166 (45.1)
Total	**368**

Currently Practicing in Oncology	
Yes	334 (90.8)
Length of Time Working (yrs)	
Over 30	3 (0.9)
25-29	71 (21.3)
20-24	83 (24.9)
15-19	54 (16.2)
10-14	40 (12)
5-9	31 (9.3)
1-4	28 (8.4)
Under 1	23 (6.9)
No	34 (9.2)
Length of Time Since Working (yrs)	
Under 1	19 (59.4)
1-5	6 (18.8)
6-10	5 (15.6)
11-20	2 (6.3)
Over 20	0
Total	**368**
Ruralality	
Rural	77 (23.1)
Urban	257 (76.9)
Total	**334**
Type of Work Setting	
Inpatient Oncology Unit	123 (36.8)
Ambulatory /Outpatient Center	125 (37.4)
Hospice/Palliative Care	20 (6.0)
Pain Management	0
Cancer Risk Assessment Center	1 (0.3)
Home Health	1 (0.3)
University/College Setting	10 (3.0)
Physician's Office	31 (9.3)
Research/Laboratory	17 (5.1)
Other	4 (1.2)
Total	**334**
Communication Behavior	
Utilizes 2 or Less Forms of Media	196 (53.3)
Utilizes 3-4 Forms of Media	150 (40.8)
Utilizes 5-6 Forms of Media	22 (6)
Total	**368**

[a] OCN: Oncology Certified Nurse; [b] CPON: Certified Pediatric Oncology Nurse; [c] CPHON: Certified Pediatric Hematology/Oncology Certified Nurse ; [d] AOCN: Advanced Oncology Certified Nurse; [e] CBCN: Certified Breast Care Nurse; [f] AOCNP: Advanced Oncology Certified Nurse Practitioner; [e] AOCNS: Advanced Oncology Clinical Nurse Specialist

Pharmacogenomic Testing Utilization

Over 69% of the participants revealed that they have heard the term pharmacogenomics or pharmacogenetics. In addition, 54% of the respondents do not work at a pharmacogenomic testing research site (Table 3). Fifty one percent of the participants indicated that they were unsure whether pharmacogenomic testing is available at their place of employment. Furthermore, 47.8% of the respondents stated that they have cared for a patient who has had a pharmacogenomic test, whereas greater than 75% of the nurses stated that they have never educated a patient regarding pharmacogenomic testing nor advocated for any of their patients to undergo pharmacogenomic testing. Finally, 62% of the study participants felt that they use pharmacogenomic testing information sometimes in their nursing care.

In addition, the Nursing Practice Questionnaire was also given to the respondents. The Cronbach's alpha for this scale was 0.59. The average among this sample was 1.92 with a standard deviation of 0.95 (Table 4). Therefore, on average, the respondents are within the awareness stage regarding pharmacogenomic testing.

Statistical Analyses

Descriptive statistics were performed for Aim #1. For Aim #2, #3, and #4, both descriptive and correlational statistics were performed.

Aim # 1 Analyses

For Aim #1, analyses addressed the following research questions, "what is the perceived and actual knowledge of oncology nurses in the state of North Carolina about basic genomic and pharmacogenomic testing," "what attitudes do oncology nursing in the

Table 3: Pharmacogenomic Testing Utilization	**n (%)**
Ever Cared for Patient who Received a Pharmacogenomic Test	
Yes	176 (47.8)
No	73 (19.8)
Unsure	119 (32.3)
Total	**368**
Ever Educated a Patient about Pharmacogenomic Testing	
Yes	85 (23.1)
No	283 (76.9)
Total	**368**
Ever Advocated for a Patient to Undergo Pharmacogenomic Testing	
Yes	89 (24.2)
No	279 (75.8)
Total	**368**
Pharmacogenomic Tests Available	
Yes	111 (30.2)
No	69 (18.8)
Unsure	188 (51.1)
Total	**368**
Association with Pharmacogenomic Testing Site	
Yes	181 (54.2)
No	153 (45.8)
Total	**334**

Table 4: Nursing Practice Questionnaire	**n (%)**
Unaware	27 (7.3)
Aware	102 (27.7)
Persuasion	114 (31)
Adoption	125 (34)
Total	**368**
Mean	1.92
SD	0.95
Range	0-3

state of North Carolina have concerning pharmacogenomic testing," and "what is the support for use of pharmacogenomic testing in the oncology field throughout the state of

North Carolina"? In addition, there were questions concerning previous knowledge of genomics and pharmacogenomics. Perceived knowledge responses were coded 1-5 for poor to excellent, with higher scores indicating better perceived knowledge. Responses for previous knowledge were coded: 1 for yes and 0 for no.

Fifty-eight percent of the respondents revealed that they have had previous genomic education (Table 5). The majority (59%) of the respondents have had this education since 2010. Over 68% of the study participants feel that they have a fair or poor understanding of genetics (Figure 3). Additionally, 62.5% of the participants have never had any pharmacogenomic education. Seventy two percent of the respondents rated their perceived knowledge of pharmacogenomic testing as fair or poor as well (Figure 4).

Five questions assessed actual genetic knowledge and five questions assessed actual pharmacogenomic knowledge. The possible range for actual genetic knowledge and actual pharmacogenomic knowledge was 0-5. The possible range for total knowledge was 0-10. Additionally, Cronbach's alpha was calculated for each scale.

The basic genomic knowledge scale had an alpha of 0.68 and pharmacogenomic knowledge scale had an alpha of 0.67. The total actual knowledge scale had an alpha of 0.64.

The mean actual genomic knowledge score was 2.45 with a standard deviation of 1.4 (Table 6). In addition, the mean actual pharmacogenomic score was 2.61 with a standard deviation of 1.44. Finally, the mean total genomic knowledge score was 5.09 with a standard deviation of 2.43.

The mean score for attitude towards pharmacogenomic testing in general was 14.1 with a standard deviation of 3.9 (Table 7). Furthermore, the mean score for attitude

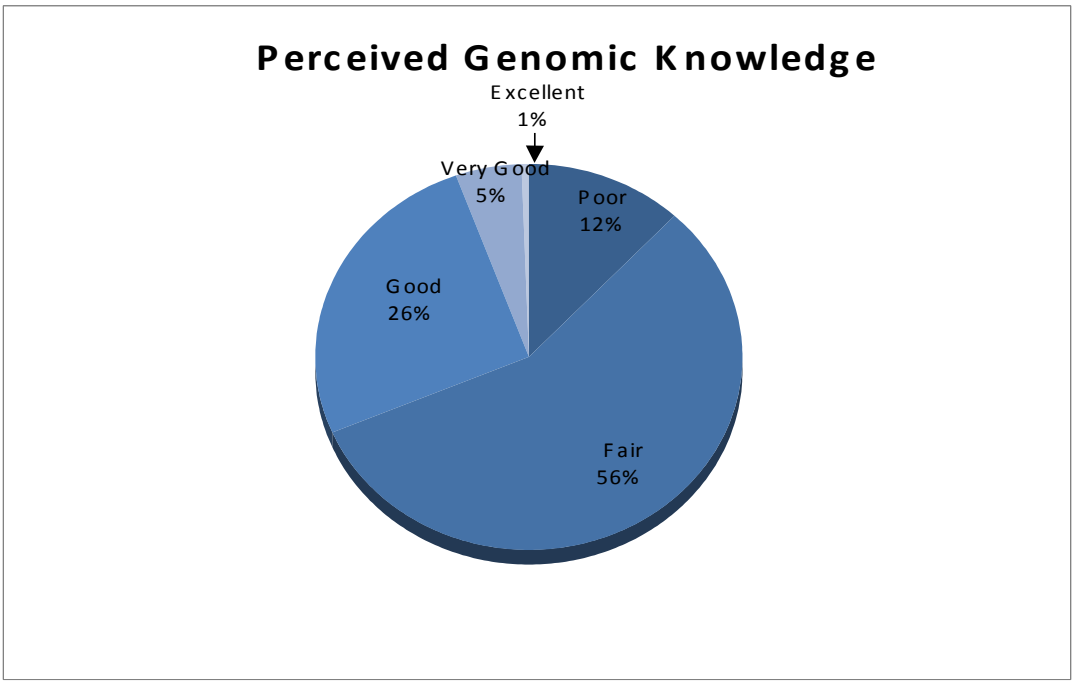


Figure 3: Perceived Genomic Knowledge

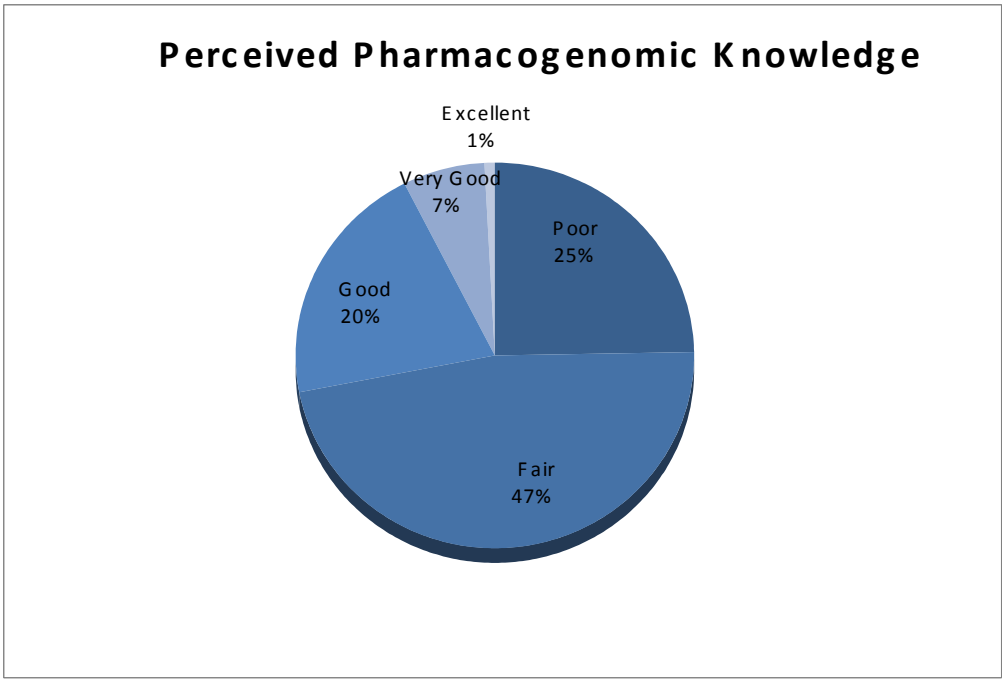


Figure 4: Perceived Pharmacogenomic Knowledge

Table 5: Perceived Knowledge	**n (%)**
Previous Genomic Education	
Yes	214 (58.2)
Last Course Taken	
Since 2010	88 (58.7)
2005-2009	33 (22)
2000-2004	13 (8.7)
1990's	7 (4.7)
1980's	4 (2.7)
1970's	5 (3.3)
No	154 (41.8)
Total	**368**
Perceived Genomic Knowledge	
Poor	44 (12)
Fair	208 (56.5)
Good	96 (26.1)
Very Good	18 (4.9)
Excellent	2 (0.5)
Total	**368**
Previous Pharmacogenomic Education	
Yes	138 (37.5)
No	230 (62.5)
Total	**368**
Perceived Pharmacogenomic Knowledge	
Poor	91 (24.7)
Fair	174 (47.3)
Good	75 (20.4)
Very Good	25 (6.8)
Excellent	3 (0.8)
Total	**368**

towards pharmacogenomic testing related to oncology was 9.2 with a standard deviation of 2.9. Finally, the overall attitude towards pharmacogenomic testing produced a mean score of 23.3 and a standard deviation of 6.1. The general attitude scale had an alpha of 0.69, whereas the attitude scaled related to oncology had an alpha of 0.76. Finally, the overall attitude scale had an alpha of 0.70. Each individual attitude question is addressed in Table 8 with frequency and percentages.

Table 6: Actual Genomic Knowledge n=362-368	**Correct (%)**
Item 1	149 (40.5)
Item 2	217 (59)
Item 3	157 (42.7)
Item 4	112 (30.4)
Item 5	272 (73.9)
Basic Genomic Score	
Mean	2.45
Range	0-5
SD	1.4
Item 6	308 (83.7)
Item 7	192 (52.2)
Item 8	72 (19.6)
Item 9	208 (56.5)
Item 10	187 (50.8)
Pharmacogenomic Score	
Mean	2.61
Range	0-5
SD	1.44
Total Score	
Mean	5.09
Range	0-10
SD	2.43

Lastly, study participants were asked one question related to support for use of pharmacogenomic testing. The range for this question was 0-2. The respondents were asked how often they utilize pharmacogenomic testing information in their nursing care. The three choices were 'never', 'sometimes', and 'always' which were coded 0, 1, and 2, respectively. The mean score for the support for use of pharmacogenomic testing was 1.33 with a standard deviation of 0.52 (Table 9).

Summary. Oncology nurses who participated in this study felt that they do not have fair knowledge of both genomics and pharmacogenomic testing based on their

Table 7: Attitude Scales	
General Attitude	
Mean	14.1
Range	7-20
SD	3.9
Attitude toward Pharmacogenomics Related to Oncology	
Mean	9.2
Range	6-18
SD	2.9
Overall Attitude	
Mean	23.3
Range	13-38
SD	6.1

perceived genomic knowledge. The results revealed that oncology nurses' actual understanding of genomics was about the same as their own perception of their knowledge based on the fact that they answered about half of the genomic and pharmacogenomic testing questions correctly.

In general, attitudes towards pharmacogenomic testing were overall positive. Attitudes specifically related to oncology had a more favorable response than attitudes towards pharmacogenomic testing in general. Furthermore, the majority of the participants revealed that they utilize pharmacogenomic testing information sometimes to always in their nursing care. A minimal amount of oncology nurses stated that they never utilize this type of information in their nursing care.

Aim #2 Analyses

Aim #2 analyses addressed the following research question, "what are the relationships between actual knowledge of oncology nurses in the state of North Carolina concerning basic genomic and pharmacogenomic testing and the variables: prior

Table 8: Attitude Scale Items	**n (%)**
Perceived Need of Pharmacogenomics	
Yes	326 (89.1)
No	40 (10.9)
Total	**366**
Believe in Education Patients about Pharmacogenomics	
Yes	278 (76.6)
No	85 (23.4)
Total	**363**
Fear Unauthorized Access	
Not Concerned	122 (33.4)
Somewhat Concerned	150 (41)
Concerned	64 (17.4)
Very Concerned	29 (8.2)
Total	**365**
Fear Discrimination	
Not Concerned	85 (23.1)
Somewhat Concerned	137 (37.2)
Concerned	87 (23.6)
Very Concerned	59 (16)
Total	**368**
Fear Family will be Affected	
Not Concerned	82 (22.3)
Somewhat Concerned	154 (41.9)
Concerned	80 (21.7)
Very Concerned	52 (14.1)
Total	**368**
Trust	
Strongly Distrust	7 (1.9)
Distrust	108 (29.4)
Trust	194 (52.7)
Strongly Trust	59 (16)
Total	**368**
Decrease Adverse Drug Events	
Yes	296 (80.3)
No	12 (3.3)
Unsure	60 (16.3)
Total	**368**
Decrease Costs of Prescription Medicine	
Yes	116 (31.5)
No	129 (35.1)
Unsure	123 (33.4)
Total	**368**
Relative Advantage	
Yes	346 (95.4)
No	17 (4.6)
Total	**363**

Believe Tamoxifen is Genetically Based	
Yes	233 (63.3)
No	7 (1.9)
Unsure	128 (34.8)
Total	**368**
Believe Tumor-Profiling is Useful	
Yes	311 (84.5)
No	5 (1.4)
Unsure	52 (14.1)
Total	**368**
Comfortable Using Pharmacogenomics	
On Your Patient	
Not Comfortable	20 (5.4)
Somewhat Comfortable	75 (20.7)
Comfortable	175 (48.4)
Very Comfortable	92 (25.5)
Total	**362**
On Yourself	
Not Comfortable	14 (3.8)
Somewhat Comfortable	58 (16)
Comfortable	138 (38)
Very Comfortable	152 (42)
Total	**362**

Table 9: Support for Use	**n (%)**
Support for Use	
Never Use	231 (63.6)
Sometimes Use	132 (36.4)
Always Use	0 (0)
Total	**363**
Mean	1.33
Range	0-2
SD	0.52

experience with pharmacogenomic testing, innovativeness, perceived need of innovation, work setting, ruralality, communication behavior, and personality variables such as age, years of experience in the oncology setting, education level, certification in oncology, currently practicing in oncology field, time since last genetic and pharmacogenomic education, association with a pharmacogenomic testing research site and perceived

genetic and pharmacogenomic testing knowledge"? Before any statistical analysis could be performed, the innovativeness score for each respondent was first calculated (Table 10). The Cronbach's alpha for this scale was 0.73. Additionally, the frequency and percentages of each innovator type for this sample was calculated (Table 10). This study sample consisted of 17.4% innovators, 47.8% early adopters, 28.8% of early majority, 5.4% late majority, and 0.5% as traditionalists. Figure 5 shows the rate of adoption and normal percentages for each innovator type.

Table 10: Innovativeness	**n (%)**
Innovator Type	
Innovator	64 (17.4)
Early Adopter	176 (47.8)
Early Majority	106 (28.8)
Late Majority	20 (5.4)
Traditionalists	2 (0.5)
Total	**368**
Innovativeness Score	
Mean	71.95
Range	37-92
SD	9.2

Figure 5: Diffusion of Innovation according to Rogers (2003). Blue line indicates the percentages of categories that the group needs to have successful adoption of an innovation. Yellow line indicates the adoption rate of the innovation.

Secondly, a contingency table was calculated for each categorical variable and each item on the genomic knowledge scale. A Pearson's chi square test was calculated for each categorical variable to determine whether the distribution of each item differed over the levels of each categorical variable. The contingency table revealed that responses to item #41 (17.06, p=0.0044) and item #48 (12.09, p=0.0336) changed with age. Responses to item #50 (4.39, p=0.0361) changed with prior experience and responses to item #44 (15.45, p=0.0039) changed with innovativeness. Responses to item #50 (25.94, p=0.0011) changed with education level. Responses to items #43, 45, 46, 49 and 50 (8.57, p=0.0034; 7.79, p=0.0053; 9.62, p=0.0019; 6.25, p=0.0124; 20.02, p<0.0001) changed with certification in oncology nursing. Responses to item #50 (30.89, p=0.0001) changed with type of work setting. Additionally, responses to items #42, 43, 44, 45, 47, 48, and 50 (26.64, p<0.0001; 14.49, p=0.0059; 11.91, p=0.0181; 12.12, p=0.0165; 13.61, p=0.0086; 17.35, p=0.0017; 25.21, p <0.0001) changed with perceived genomic knowledge. Finally, responses to items # 42, 43, 45, 46, 48, and 50 (10.06, p=0.0395; 19.33, p=0.0007; 11.36, p=0.0228; 12.95, p=0.0115; 10.77, p=0.0293; 25.26, p<0.0001) changed with perceived pharmacogenomic knowledge.

Furthermore, a one-way ANOVA was conducted to determine whether the total score for the knowledge questions differ significantly within each of the variables (Table 11). There was a significant effect of perceived basic genomic knowledge on the total actual knowledge score [F(4, 328)=10.97, p<0.0001]. A Bonferroni post-hoc test was completed and the categories of poor and fair perceived genomic knowledge were combined due to their similarity. Also there was a significant effect of previous genomic education [F(1, 331)=14.36, p=0.0002] and previous pharmacogenomic education [F(1,

Table 11: ANOVA- Actual Overall Genomic Knowledge	**β**	**df1, df2**	**F**	**p**
Age		5, 327	2.22	0.0673
Degree		8, 324	0.64	0.7456
Certification		1, 331	10.02	0.0017
Yes	0.00			
No	-0.68			
Currently Working		1, 331	0	0.9494
Ruralality		1, 331	0.60	0.0115
Rural	-0.65			
Urban	0.00			
Associated with Pharmacogenomic Research Site		1, 331	0.51	0.4749
Work Setting		7, 325	0.52	0.8208
Previous Genomic Education		1, 331	5.94	0.0154
Yes	0.00			
No	-0.44			
Perceived Genomic Knowledge		4, 328	2.9	0.0224
Poor	-2.34			
Fair	-1.85			
Good	-0.62			
Very Good	-1.30			
Excellent	0.00			
Perceived Pharmacogenomic Knowledge		4, 328	0.29	0.8829
Previous Pharmacogenomic Education		1, 331	9.94	0.0018
Yes	0.00			
No	-0.28			
Available Pharmacogenomic Tests		2, 330	8.06	0.0004
Yes	0.69			
No	0.33			
Unsure	0.00			
Prior Experience		2, 330	18.57	<0.0001
Yes	0.32			
No	0.00			
Perceived Need		1, 331	3.58	0.0594
*$\beta_{0:}$ 7.03				

331)=9.94, p=0.0018] on the total actual knowledge score. Also availability of pharmacogenomic tests [F(2, 330)=8.06, p=0.0004] and prior experience with pharmacogenomic testing [F(2, 330]=18.57, p<0.0001] had a significant effect on the total actual knowledge score. Furthermore, there was a significant effect of ruralality on total actual knowledge score [F(1, 331)=4.50, p=0.0348]. Finally, there was a significant effect of certification on total actual knowledge score [F(1, 331)=10.02, p=0.0017].

In addition, a one-way ANOVA was conducted with the dependent variable of actual basic genomic knowledge score (Table 12). There was a significant effect of age [F(5, 327)=2.85, p=0.0244], perceived genomic knowledge [F(4, 328)=10.48, p<0.0001], previous genomic education [F(1, 331)=5.05, p=0.0253], perceived need of pharmacogenomic testing [F(1, 331)=13.04, p<0.0001], prior experience [F(2, 330)=5.38, p=0.0209], ruralality [F(1, 331)=5.11, p=0.0246], and whether or not respondent has certification in oncology [F(1, 331)=7.57, p=0.0063]. A Bonferroni post-hoc test was completed and the categories of poor and fair perceived genomic knowledge were combined due to their similarity. In addition, the age groups of 18-29 and 30-39 were combined based on the Bonferroni test as well as 40-49 and 50-59 years. Finally, a one-way ANOVA was conducted with the dependent variable of actual pharmacogenomic knowledge (Table 13). There was a significant effect across perceived genomic knowledge [F(4, 328)=7.66, p<0.0001], previous genomic education [F(1, 331)=19.08, p<0.0001], previous pharmacogenomic education [F(1, 331)=17.09, p<0.0001], prior experience [F(2, 330)=24.63, p<0.0001], available pharmacogenomic tests [F(2, 330)=13.96, p=0.0003], and certification in oncology [F(1, 331)=9.90, p=0.0018]. A Bonferroni post-hoc test was completed and the categories of poor and fair perceived

Table 12: ANOVA-Basic Genomic Knowledge	**β**	**df1, df2**	**F**	**p**
Age		5, 327	2.85	0.0244
18-29	2.76			
30-39	2.50			
40-49	2.22			
50-59	2.05			
60-69	1.74			
70 or greater	0.00			
Degree		8, 324	0.39	0.928
Certification		1, 331	7.57	0.0063
Yes	0.00			
No	-0.34			
Currently Working		1, 331	0.64	0.4239
Ruralality		1, 331	5.11	0.0246
Rural	-0.39			
Urban	0.00			
Associated with Pharmacogenomic Research Site		1, 331	0.75	0.3880
Work Setting		7, 325	0.43	0.8814
Previous Genomic Education		1, 331	5.05	0.0253
Yes	0.00			
No	-0.27			
Perceived Genomic Knowledge		4, 328	10.48	<0.0001
Poor	-1.87			
Fair	-1.33			
Good	-0.72			
Very Good	-0.61			
Excellent	0.00			
Perceived Pharmacogenomic Knowledge		4, 328	0.45	0.7744
Previous Pharmacogenomic Education		1, 331	3.75	0.0535
Available Pharmacogenomic Tests		2, 330	3.02	0.0502
Prior Experience		2, 330	13.04	<0.0001
Yes	0.17			
No	0.00			
Perceived Need		1, 331	5.38	0.0209
Yes	0.12			
No	0.00			
*β_0: 1.55				

Table 13: ANOVA- Pharmacogenomic Knowledge	**β**	**df1, df2**	**F**	**p**
Age		5, 327	1.22	0.3008
Degree		8, 324	0.93	0.4930
Certification		1, 331	9.9	0.0018
Yes	0.00			
No	-0.41			
Currently Working		1, 331	1.03	0.3108
Ruralality		1, 331	1.87	0.1723
Association with Pharmacogenomic Research Site		1, 331	1.02	0.3122
Work Setting		7, 325	1.97	0.0593
Previous Genomic Education		1, 331	19.08	<0.0001
Yes	0.00			
No	-0.31			
Perceived Genomic Knowledge		4, 328	7.66	<0.0001
Poor	-0.63			
Fair	-0.64			
Good	-0.01			
Very Good	-0.87			
Excellent	0.00			
Perceived Pharmacogenomic Knowledge		4, 328	0.43	0.7868
Previous Pharmacogenomic Education		1, 331	17.09	<0.0001
Yes	0.00			
No	-0.27			
Available Pharmacogenomic Tests		2, 330	13.96	0.0003
Yes	0.47			
No	0.39			
Unsure	0.00			
Prior Experience		2, 330	24.63	<0.0001
Yes	0.17			
No	0.00			
Perceived Need		1, 331	0.71	0.3993
*β_0: 3.31				

genomic knowledge were combined due to their similarity. Also multicollinearity was not found among any of these variables.

Finally, regression models were generated for each of the knowledge scores, basic genomic knowledge, pharmacogenomic testing knowledge, and the combination of the scores. The significant predictors that were found in the one-way ANOVA were utilized as indicator variables in the regression models. A forward regression model was initially conducted. Then a backward elimination was performed. Finally, a stepwise regression model was conducted.

The forward and stepwise regression model for total genomic knowledge revealed that four indicator variables, certification in oncology, prior experience, previous genomic education, and perceived genomic knowledge, created a significant model [$F=(4, 363)=20.44$, $p<0.0001$] (Table 14). However, a backward elimination concluded five indicator variables with the addition of the demographic variables [$F(5, 362)=17.06$, $p<0.0001$]. After both models were compared utilizing AIC, BIC, and PRESS criteria to determine the best model, the forward elimination model was found to be the best model because it had the lowest AIC, BIC, and PRESS (O'Meara, 2012).

A significant model for basic genomic knowledge scores was identified by utilizing forward regression modeling to reveal five indicator variables: age, oncology certification, perceived genomic knowledge, ruralality, and perceived need [$F(6, 361)=13.85$, $p<0.0001$] (Table 14). A stepwise regression revealed the same results. However, a backward elimination found an additional indicator variable: previous

education in genomics [$F(7, 360)=12.25$, $p<0.0001$]. The backward elimination model was found to be the best model because it had the lowest AIC, BIC, and PRESS.

Finally, a forward regression technique for pharmacogenomic knowledge scores were used and determined that oncology certification, previous genomic education and prior experience were significant indicator variables [$F(3, 364)=26.55$, $p<0.0001$] (Table 14). A backward elimination and stepwise regression identified the same model. Residual analyses were completed for all significant models and no outliers were found.

Summary. This study revealed that total actual genomic knowledge was significantly associated with multiple personality variables including perceived basic genomic knowledge, previous genomic education, and certification acquisition, prior experience with pharmacogenomic testing as well as ruralality. Perceived need of pharmacogenomic testing, innovativeness, work environment, and communication behavior were not significantly associated with the total genomic knowledge score.

Oncology nurses who had a higher perceived basic genomic knowledge, previous genomic and pharmacogenomic education, prior experience with pharmacogenomic testing, an oncology certification in nursing, and working in an urban area had a significantly higher mean actual knowledge score. Furthermore, the regression model indicated that total genomic knowledge was more accurately predicted by prior experience with pharmacogenomic testing and personality variables: certification in oncology nursing, perceived genomic knowledge, and previous genomic education. Actual basic genomic knowledge was influenced by several factors within the guiding framework including ruralality, prior experience, perceived need, and personality variables: age, perceived genomic knowledge, previous genomic education, and

Table 14: Regression for Knowledge		**F**	**R^2**	**β**	**SEβ**
Overall Knowledge	Perceived Knowledge	20.44	0.18	0.74	0.17
	Previous Genomic Education			0.63	0.26
	Certification			0.69	0.25
	Prior Experience			0.39	0.14
	Ruralality[1]			-	-
Basic Genomic Knowledge	Perceived Knowledge	12.25	0.19	0.47	0.09
	Certification			0.35	0.14
	Prior Experience			0.31	0.13
	Perceived Need			0.54	0.22
	Age			-0.24	0.06
	Ruralality			0.38	0.17
	Previous Genomic Education			0.25	0.15
Pharmacogenomic Knowledge	Certification	26.55	0.18	0.46	0.15
	Prior Experience			0.24	0.10
	Previous Genomic Education			0.44	0.16
[1]: Included only in backward elimination					

certification attainment in oncology nursing. This study revealed that oncology nurses who had a higher perceived basic genomic knowledge score, previous genomic education, oncology certification, younger age, worked in an urban area, prior experience with pharmacogenomic testing, and perceived need for pharmacogenomic testing had a significantly higher total actual basic knowledge score.

Furthermore, the regression model indicated that total basic genomic knowledge was more accurately predicted by prior experience with pharmacogenomic testing, ruralality, perceived need of pharmacogenomic testing, and personality variables: age, certification in oncology nursing, perceived genomic knowledge, and previous genomic education.

Actual pharmacogenomic knowledge was influenced by several factors associated with the guiding theory. Prior experience and personality variables of perceived genomic knowledge, previous genomic and pharmacogenomic education, and certification attainment in oncology nurses significantly influence knowledge of pharmacogenomic testing. Respondents with a higher perceived knowledge, certification in oncology nursing, prior experience with pharmacogenomic testing, and previous genomic and pharmacogenomic education had a higher total pharmacogenomic knowledge score. Moreover, the regression model indicated that total pharmacogenomic knowledge was more accurately predicted by the personality variables: certification in oncology nursing, perceived genomic knowledge, and previous genomic education.

Therefore, Aim # 2 was partially supported in addressing which relationships were associated with actual knowledge of oncology nurses in the state of North Carolina and only a few of the variables successfully predicted the dependent variable of actual knowledge.

Aim # 3 Analyses

Aim # 3 analyses addressed the following research question, "what are the relationships between attitudes of oncology nurses in the state of North Carolina concerning pharmacogenomic testing and the variables: relative advantage, compatibility,

complexity, trialability, and observability of the innovation, actual genomic and pharmacogenomic testing knowledge, prior experience with pharmacogenomic testing, innovativeness, perceived need of innovation, work setting, ruralality, communication behavior, and personality variables such as age, education level, certification in oncology, currently practicing in oncology field, association with a pharmacogenomic testing research site and perceived genomic and pharmacogenomic testing knowledge"?

The same statistical analyses conducted in Aim # 2 were also performed for this Aim. A contingency table was calculated for each categorical variable and each item on the attitude scale. The contingency table revealed that feeling comfortable utilizing pharmacogenomic testing on oneself was not associated with relative advantage (9.18, $p=0.0270$). Also perceived usefulness of tumor profiling (97.25, $p <0.0001$) and belief that Tamoxifen is genetically determined (30.76, $p<0.0001$) were not associated with relative advantage. Also belief that pharmacogenomic testing would decrease cost of medications (8.20, $p=0.0042$) and decrease in adverse drug reactions (73.27, $p<0.0001$) were not associated with relative advantage. Furthermore, feeling comfortable utilizing pharmacogenomic testing on their patient or oneself, perceived usefulness of tumor profiling, belief that pharmacogenomic testing would decrease cost of medications and decrease in adverse drug reactions (8.09, $p=0.0442$; 9.49, $p=0.0235$; 51.31, $p<0.0001$; 13.56, $p=0.0002$; 127.64, $p <0.0001$ 68.10, $p<0.0001$) were not associated with complexity. Perceived usefulness of tumor profiling, belief that Tamoxifen is genetically determined, and belief that oncology is a promising area for pharmacogenomic testing (3.90, $p=0.0482$; 4.90, $p= 0.0269$; 12.13, $p=0.0005$) were not associated with prior experience.

Furthermore, a one-way ANOVA was conducted to determine whether the overall attitude differs significantly within each of the variables (Table 15). There was a significant effect of communication behavior [$F(2, 365)=6.52$, $p=0.0017$], prior experience [$F(2, 365)=96.61$, $p<0.0001$], observability of pharmacogenomic testing [$F(2, 365)=4.29$, $p=0.0146$], trialability [$F(2, 365)=5.12$, $p=0.0018$], relative advantage [$F(1, 366)=41.45$, $p<0.0001$], and perceived need of pharmacogenomic testing [$F(1, 366)=10.07$, $p=0.0017$] on the total overall attitude score. A Bonferroni post-hoc test was completed and the categories within the communication behavior of greater than three modes of communication were combined due to their similarity. Also multicollinearity was not found among any of these variables.

In addition, a one-way ANOVA was conducted with the dependent variable of general attitude of pharmacogenomic testing (Table 16). There was a significant effect of highest educational degree obtained [$F(8, 359)=2.07$, $p=0.0383$], perceived need of pharmacogenomic testing [$F(1, 366)=6.45$, $p=0.0116$], prior experience [$F(1, 366)=96.61$, $p<0.0001$], communication behavior [$F(2, 365)=1.21$, $p=0.0163$], trialability [$F(2, 365)=4.84$, $p=0.0026$], and relative advantage [$F91, 366)=26.21$, $p<0.0001$]. A Bonferroni post-hoc test was completed and the categories within the communication behavior of greater than three modes of communication were combined due to their similarity. In addition, the post-hoc analysis determined that the Doctorate of Nursing Practice (DNP) and LPN categories had similar general attitude towards pharmacogenomic testing. Finally, a one-way ANOVA was conducted with the dependent variable of attitude toward pharmacogenomic testing specifically related to oncology (Table 17). There was a significant effect across previous genomic education

Table 15: ANOVA-Overall Attitude	**β**	**df1, df2**	**F**	**p**
Age		5, 362	0.60	0.7023
Degree		8, 359	1.39	0.1997
Certification		1, 366	1.47	0.2270
Currently Working		1, 366	0.02	0.8970
Ruralality		1, 366	3.11	0.0787
Associated with Pharmacogenomic Research Site		1, 366	77.76	0.1053
Work Setting		7, 360	1.86	0.0661
Previous Genomic Education		1, 366	1.79	0.1821
Perceived Genomic Knowledge		4, 363	0.94	0.4387
Perceived Pharmacogenomic Knowledge		4, 363	1.17	0.3253
Previous Pharmacogenomic Education		1, 366	0.08	0.7787
Available Pharmacogenomic Tests		2, 365	4.29	0.0146
Yes	-1.97			
No	-1.55			
Unsure	0.00			
Perceived Need		1, 366	10.07	0.0017
Yes	0.00			
No	0.03			
Prior Experience		1, 366	96.61	<0.0001
Yes	-0.38			
No	0.00			
Educated Patient About Pharmacogenomics		1, 366	0.02	0.9021
Advocated		1, 366	0.37	0.5447
Innovativeness		4, 363	0.32	0.8678
Complexity		2, 365	2.35	0.0969
Trialability		2, 365	5.12	0.0018
Yes	-1.09			
No	1.27			
Unsure	0.00			
Relative Advantage		1, 366	41.45	<0.001
Yes	-1.45			
No	0.00			
Communication		2, 365	3.49	0.0319
Less than 2 Forms	2.03			
3-4 Forms	-0.12			
5-6 Forms	0.00			
*β_0: 24.10				

Table 16: ANOVA-General Attitude	**β**	**df1, df2**	**F**	**p**
Age		5, 362	0.79	0.5588
Degree		8, 359	2.07	0.0383
PhD	-3.28			
DNP	-5.46			
CNS	-7.29			
NP	-4.85			
MSN	-5.08			
Diploma	-4.14			
Associate	-4.18			
LPN	-3.35			
BSN	0.00			
Certification		1, 366	2.48	0.1167
Currently Working		1, 366	0.78	0.3790
Ruralality		1, 366	1.21	0.2731
Associated with Pharmacogenomic Research Site		1, 366	2.92	0.0883
Work Setting		7, 360	1.2	0.3004
Previous Genomic Education		1, 366	0.09	0.7674
Perceived Genomic Knowledge		4, 363	0.38	0.8253
Perceived Pharmacogenomic Knowledge		4, 363	0.71	0.5655
Previous Pharmacogenomic Education		1, 366	0.29	0.5878
Available Pharmacogenomic Tests		2, 365	3.16	0.0437
Yes	-1.05			
No	-0.76			
Unsure	0.00			
Perceived Need		1, 366	6.45	0.0116
Yes	0.00			
No	0.72			
Prior Experience		1, 366	96.61	<0.0001
Yes	-0.01			
No	0.00			
Educated Patient About Pharmacogenomics		1, 366	0.26	0.6138
Advocated		1, 366	0.03	0.8544
Innovativeness		4, 363	0.91	0.4576
Complexity		2, 365	1.55	0.2146
Trialability		2, 365	4.84	0.0026
Yes	-0.10			
No	-0.03			
Unsure	0.00			
Relative Advantage		1, 366	26.21	<0.001
Yes	-1.23			
No	0.00			
Communication		2, 365	4.17	0.0163
Less than 2 Forms	0.69			

3-4 Forms	-0.17			
5-6 Forms	0.00			
*β_0: 18.45				

[F(1, 366)=5.66, p=0.0179], prior experience [F(1, 366)=73.29, p<0.0001], communication behavior [F(2, 365)=6.23, p=0.0022], ruralality [F(1, 366)=4.65, p=0.0317], type of oncology setting [F(7, 360)=2.10, p=0.0356], observability of pharmacogenomic testing [F(2, 365)=4.28, p=0.0147], perceived need of pharmacogenomic testing [F(1, 366)=9.61, p=0.0021], relative advantage [F(1, 366)=40.07, p<0.0001], and trialability [F(3, 364)=3.87, p=0.0097]. A Bonferroni post-hoc test was completed and the categories within the communication behavior of greater than three modes of communication were combined due to their similarity. In addition, similar attitudes towards pharmacogenomic testing specifically related to oncology were found between inpatient oncology units and university or college settings. Multicollinearity was not found among any of these variables.

Finally, regression models were generated for each of the attitude scores, general attitude, attitude specifically related to pharmacogenomic testing in oncology, and the combination of both. The significant predictors that were found in the one-way ANOVA were utilized as indicator variables in the regression models. A forward regression model was initially conducted. Then a backward elimination was performed. Finally, a stepwise regression model was conducted.

The forward regression model for overall attitude towards pharmacogenomic testing revealed five indicator variables, communication behavior, observability, prior experience, perceived need, and relative advantage, created a significant model [F(5,

Table 17: ANOVA-Attitude Related to Oncology	**β**	**df1, df2**	**F**	**p**
Age		5, 362	1.13	0.3430
Degree		8, 359	0.36	0.9394
Certification		1, 366	0.12	0.7323
Currently Working		1, 366	0.91	0.3417
Ruralality		1, 366	4.65	0.0317
Rural	-0.73			
Urban	0.00			
Associated with Pharmacogenomic Research Site		1, 366	1.03	0.3098
Work Setting		7, 360	2.10	0.0356
Inpatient Unit	1.86			
Outpatient Unit	1.88			
Hospice	1.13			
Pain Management	-1.95			
Home Health	-0.06			
University	0.57			
Physician's Office	2.18			
Research	0.00			
Previous Genomic Education				
Yes	0.00	1, 366	5.66	0.0179
No	0.59			
Perceived Genomic Knowledge				
Perceived Pharmacogenomic Knowledge		4, 363	1.86	0.1173
Previous Pharmacogenomic Education		4, 363	1.76	0.1361
Available Pharmacogenomic Tests		1, 366	1.8	0.1813
Yes	-0.90	2, 365	4.28	0.0147
No	-0.26			
Unsure	0.00			
Perceived Need				
Yes	-0.40	1, 366	9.61	0.0021
No	0.00			
Prior Experience				
Yes	-0.21	1, 366	73.29	<0.0001
No	0.00			
Educated Patient About Pharmacogenomics				
Advocated		1, 366	0.92	0.3388
Innovativeness		1, 366	2.31	0.1295
Complexity		4, 363	0.91	0.4570
Trialability		2, 365	2.37	0.0969
Yes	-0.05	2, 365	3.87	0.0097
No	0.95			
Unsure	0.00			

Relative Advantage				
Yes	-0.23	1, 366	40.07	<0.001
No	0.00			
Communication				
Less than 2 Forms	0.69	2, 365	6.23	0.0022
3-4 Forms	-0.17			
5-6 Forms	0.00			
*β_0: 7.93				

362)=20.74, p<0.0001] (Table 18). Both the backwards and stepwise regression model revealed the same conclusion.

Regression models were also conducted for general attitude towards pharmacogenomic testing (Table 18). The forward regression model revealed four indicator variables: communication behavior, relative advantage, prior experience, and perceived need [F(4, 363)=17.69, p<0.0001]. Additionally a stepwise regression was conducted to reveal the same indicator variables. However, a backward elimination revealed six indicator variables: communication behavior, relative advantage, prior experience, trialability, highest degree obtained, and perceived need [F(6, 361)=11.11, p<0.0001]. Since two different models were found, AIC, BIC and PRESS criterion were utilized. The forward elimination model was found to be the best model because it had the lowest AIC, BIC, and PRESS.

Finally, a forward regression model for attitude towards pharmacogenomic testing specifically related to oncology revealed six indicator variables: communication behavior, relative advantage, perceived need, setting, prior experience, and observability [F(6, 361)=17.22, p<0.0001] (Table 18). A backward elimination revealed that seven indicator variables: communication behavior, oncology setting, prior experience, previous genomic education, observability, relative advantage, and perceived need,

Table 18: Regression for Attitude		**F**	**R^2**	**β**	**SE β**
Overall Attitude	Relative Advantage	20.74	0.22	4.14	0.71
	Perceived Need			-3.82	0.96
	Communication Behavior			-1.44	0.48
	Observability			0.48	0.24
	Prior Experience			3.59	0.42
General Attitude	Relative Advantage	17.69	0.14	2.02	0.47
	Perceived Need			-1.95	0.64
	Communication Behavior			-0.78	0.32
	Prior Experience			1.98	0.23
	Degree[1]			-	-
	Trailability[1]			-	-
Attitude Related to Oncology Field	Relative Advantage	17.22	0.22	2.04	0.34
	Perceived Need			-1.76	0.46
	Communication Behavior			-0.69	0.22
	Observability			0.35	0.16
	Prior Experience			1.1	0.21
	Setting			-0.08	0.03
	Previous Genomic Education[2]			-	-
[1]: Included only in backward elimination; [2]: Included only in backward elimination					

created a significant model [$F(7, 360)=15.27$, $p<0.0001$]. Additionally a stepwise regression revealed the same significant model as the forward regression model. The forward elimination model was found to be the best model because it had the lowest AIC, BIC, and PRESS. Residual analyses were completed for all significant models and no outliers were found.

Summary. Attitude (persuasion) is influenced by several factors according to Rogers' (2003). Variables that influence knowledge as well as perceived characteristics of the innovation influence one's attitude toward the innovation. Within this study, overall attitude score toward pharmacogenomic testing was influenced by communication behavior, prior experience with pharmacogenomic testing, perceived need of pharmacogenomic testing as well as characteristics of the innovation including observability, trialability, and relative advantage.

Oncology nurses who utilized less information sources, had no prior experience with pharmacogenomic testing, lower observability, trialability, and relative advantage, and a lower perceived need for pharmacogenomic testing within the area of oncology had a significantly higher overall attitude score, in which a higher score indicated a more negative attitude towards pharmacogenomic testing.

Regression models revealed that overall attitude towards pharmacogenomic testing was more accurately predicted by communication behavior, prior experience, perceived need and characteristics of the innovation including observability and relative advantage.

General attitude toward pharmacogenomic testing was influenced by several variables including perceived need of pharmacogenomic testing, communication behavior, prior experience with pharmacogenomic testing, personality variable of educational degree, and characteristics of the innovation: trialability and relative advantage.

Oncology nurses with a Bachelor's degree, lower perceived need of pharmacogenomic testing, no prior experience with pharmacogenomic testing, and less

information sources had a significantly higher general attitude score. In addition, respondents who felt that pharmacogenomic testing were not modifiable and not promising within the field of oncology also had a significantly higher general attitude score. Therefore, these respondents had a more negative opinion of pharmacogenomic testing. Regression models revealed that general attitude towards pharmacogenomic testing was more accurately predicted by communication behavior, perceived need of pharmacogenomic testing, prior experience with pharmacogenomic testing, and the characteristic of the innovation of relative advantage.

Attitude toward pharmacogenomic testing specifically related to the field of oncology was influenced by several variables associated with the guiding theory including previous genomic education, prior experience, ruralality, communication behavior, type of oncology setting, perceived need, and characteristics of the innovation: observability, relative advantage and trialability of pharmacogenomic testing.

Respondents with no previous genomic education, no prior experience with pharmacogenomic testing, utilized less informational sources, lower observability, trialability, and relative advantage, worked in an urban, worked in a physician's office, and a lower perceived need of pharmacogenomic testing had a negative attitude score towards pharmacogenomic testing specifically related to the field of oncology. Regression models revealed that attitude towards pharmacogenomic testing specifically related to the oncology field was more accurately predicted by communication behavior, perceived need of pharmacogenomic testing, prior experience with pharmacogenomic testing, and characteristics of the innovation: relative advantage and observability.

Aim # 3 was partially supported in addressing which relationships were

associated with attitudes of oncology nurses in the state of North Carolina and only a few of the variables successfully predicted the dependent variable of overall attitude, general attitude and attitude specifically related to oncology.

Aim # 4 Analyses

Aim # 4 analyses addressed the following research question, "what are the relationships between the support for use of pharmacogenomic testing in the oncology field and the following variables: actual genomic and pharmacogenomic testing knowledge, overall attitudes towards pharmacogenomic testing, attitudes specifically related to Tamoxifen, age, years of experience in the oncology setting, education level, certification in oncology, currently practicing in oncology field, time since last genomic and pharmacogenomic education, association with a pharmacogenomic testing research site and perceived genomic and pharmacogenomic testing knowledge?

The same statistical analyses conducted in Aims # 2 and # 3 were also performed for this Aim. A contingency table was calculated for each categorical variable with support for use of pharmacogenomic testing. A Pearson's chi square test was calculated for each categorical variable to determine whether the distribution of each item differed over the levels of each categorical variable. The contingency table revealed that work setting (19.57, p=0.012) was not associated with support for use.

Furthermore, a one-way ANOVA was conducted to determine whether support for use differ significantly within each of the variables (Table 19). There was a significant effect of perceived basic genomic knowledge on the support for use of pharmacogenomic testing [F(4, 363]=2.61, p =0.0357]. A Bonferroni post-hoc test was completed and the categories of poor and fair perceived genomic knowledge were

combined due to their similarity. Multicollinearity was not found among any of these variables.

Table 19: ANOVA- Support of Use	**β**	**df1, df2**	**F**	**p**
Age		5, 362	0.91	0.4720
Degree		8, 361	0.29	0.9681
Certification		1, 366	0.09	0.7586
Currently Working		1, 366	0.66	0.4189
Ruralality		1, 366	0.39	0.5331
Association with Pharmacogenomic Research Site		1, 366	1.58	0.2093
Work Setting		7, 360	1.79	0.0786
Perceived Genomic Knowledge		4, 363	2.61	0.0357
Poor	-0.364			
Fair	-0.361			
Good	-0.365			
Very Good	-0.333			
Excellent	0.00			
Perceived Pharmacogenomic Knowledge		4, 363	2.04	0.0889
*β_0: 2.0				

Finally, regression models were generated for support for use of pharmacogenomic testing (Table 20). The forward regression model, backward elimination and stepwise regression model for support for use revealed that perceived basic genomic knowledge created a significant model [F(4, 363)=11.35, p=0.0008]. Residual analyses were completed for all significant models and no outliers were found.

Summary. Support for use was only influenced by perceived basic genomic knowledge. Respondents with higher perceived basic genomic knowledge had more support for use. Regression models to support the finding that support for use was

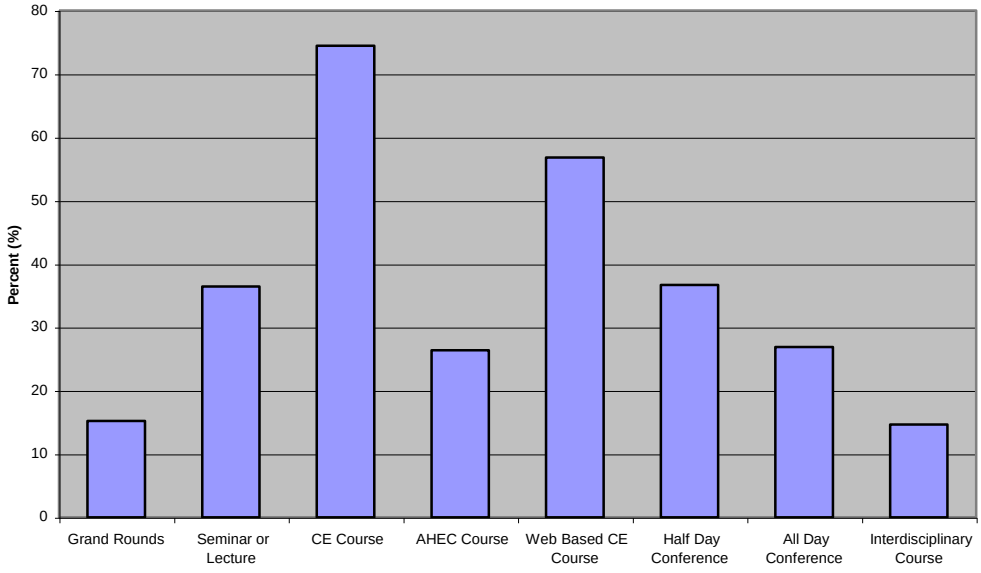
accurately predicted by perceived genomic knowledge. Aim # 4 was partially supported in addressing which relationships were associated with support for use of oncology nurses in the state of North Carolina and only a one variable successfully predicted the dependent variable of support for use.

Table 20: Regression for Support for Use		**F**	**R^2**	**β**	**SE β0**
	Perceived Genomic Knowledge	11.35	0.03	0.12	0.036

Interest in Continuing Education

An additional question assessed interest in continuing education regarding pharmacogenomic testing. Figure 6 indicates the interest in continuing education among oncology nurses in North Carolina, which revealed that they were more interesting in CE web-based or classroom courses.

Figure 6: Continuing Education Interest



Summary

Descriptive statistics were completed for Aim #1, which included univariate analysis as well as frequency and percentage analyses. Additionally, contingency tables were created for each item on the knowledge and attitude scales as well as support for use. An ANOVA was completed for each dependent variable to determine indicator variables appropriate for utilization in regression models. Finally, variable selection methods were conducted to determine the best fitting model for each dependent variable within each aim.

Chapter V

Discussion

Rogers' Diffusion of Innovation theory guided this study to assess the adoption of pharmacogenomic testing into the oncology practice by assessing oncology nurses' knowledge, attitudes, and support for use of pharmacogenomic testing. Within this chapter, the key findings and conclusions are addressed. Discussion of limitations of the study, implications for education and practice, and recommendations for future research are also presented.

Key Findings

Perceived and actual knowledge (Awareness). Findings from this study were consistent with Roederer et al.'s (2012) study that assessed perceived and actual knowledge of pharmacogenomic testing among pharmacists. Both studies revealed poor to fair perceived knowledge of genomic and pharmacogenomic testing, which corresponded with the assessment of their actual knowledge in which the respondents only answered about half of the questions correctly. Van Riper et al. (2012) also found the same results within their study which included multiple disciplines. No study has been conducted with solely nurses assessing their perceived and actual knowledge; however, the perceived knowledge findings did coincide with Dodson & Lewellan (2011) in which nursing students felt that they had a poor perceived knowledge of genomics.

Attitude (Persuasion) toward pharmacogenomic testing. The findings were similar to the other published literature. Roederer et al. (2012) pharmacists had an

overall positive attitude regarding pharmacogenomic testing. Pharmacists had an overall mean score of 3.9 out of 5 for how comfortable they are with determining their initial dose of Warfarin; in which 5 was positive and 1 was a more negative attitude (Roederer et al., 2012). Additionally, these pharmacists felt that pharmacogenomic testing would lead to decreased adverse drug reactions and better patient outcomes. Similarly, El-Ibiary (2008) concluded that pharmacists had a positive attitude towards pharmacogenomic testing as well. Several studies concluded mixed attitudes towards pharmacogenomic testing (Avard et al., 2009; Egalite et al., 2007; Fargher et al., 2007; Hoop et al., 2010; Rogausch et al., 2006). However, Hedgecoe (2006), Kadafour et al. (2009), and Tamaoki et al. (2007) found a more negative attitude towards pharmacogenomic testing among clinicians. These studies were conducted much earlier than the former studies, which may reveal that the findings from this study as well as the more recent studies suggest that attitudes concerning pharmacogenomic testing among clinicians are becoming more positive.

Support for use (Decision). No other study has been conducted with nurses on their utilization of pharmacogenomic testing. Therefore this study enhances the literature to provide an understanding of how nursing utilizes pharmacogenomic testing within their practice.

Innovativeness. According to Rogers (2003), the superlative rate of adoption follows an S curve when plotted over time as seen in Figure 3. Based on normal populations, innovators consisted of 2.5% of the population, 13.5% were early adopters, 34% were early majority, 34% were late majority, and 16% were traditionalists. According to the results, this study had far more innovators and early adopters.

Furthermore, the percentage of late majority and traditionalist were extremely low. According to Rogers (2003), the adoption of the innovation quickly occurs once the early adopters adopt the new innovation. Since this sample has more innovators and early adopters than the typical percentages, the rate of adoption may increase for this sample, which may lead to the early uptake of innovation by this sample. However, oncology nurses who are laggards or are a part of the late majority may have not even completed the survey, which may have lead to a skewed distribution of the degree of innovativeness for oncology nurses. Therefore, these results should be scrutinized before generalizing to the entire population of oncology nurses.

Concepts Related to Theory

Relationships Associated with Knowledge (Awareness)

Knowledge is influenced by several factors according to Rogers (2003). Prior conditions, including prior experience, innovativeness, perceived need, and work environment, as well as characteristics of the decision-making unit, which includes ruralality, communication behavior, and personality variables affect one's knowledge of the innovation.

Total genomic knowledge. Prior experience with the innovation was the only prior condition that was associated with total actual genomic knowledge. Perceived need, work environment and innovativeness may have not been associated with this concept for a variety of factors. Oncology nurses may have perceived a need for the innovation despite their knowledge of genomics. They may believe that the innovation is better than the current treatment available for their patients, but not necessarily have had adequate education on the topic. In addition, despite the fact that they may feel that this innovation

is needed in oncology, they may or may not be interested in learning more about genomics because they may feel that it does not directly relate to their scope of practice. Innovativeness may have not been associated with total genomic knowledge based on the fact that this sample had a different composition of categories as compared to Rogers' Diffusion of Innovation Theory (Rogers, 2003) as well as the conclusions given in the previous section on innovativeness. Work environment may not have been associated with this variable due to lack of an accurate measure of this concept. A different method of measurement for this concept needs to be addressed in order to determine whether these concepts are truly not associated with total genomic knowledge. In future studies, work environment should be measured as the degree of flexibility and creativity one has in their place of work rather than the work setting due to the fact that Rogers (2003) stated that a flexible work environment increases the rate of adoption of an innovation.

Ruralality and several personality variables such as perceived basic genomic knowledge, previous genomic education, and certification in oncology nursing was associated with this concept. Working in an urban setting had a significantly higher mean total actual genomic knowledge score which could be due to more access and better resources for knowledge acquisition pertaining to genomics in general. Certification in oncology nursing may have been associated with increased knowledge due to the requirement for continual education in oncology in order to maintain the certification. Therefore, these nurses may have an enhanced knowledge of genomics based on more exposure to continuing education courses. Also many of the continuing education courses include information on current drug therapy and tumor profiling which have a genomic component. On the other hand, communication behavior was not associated

with this concept. Communication was measured by the types of media one utilized within the last week. However, a more efficient measurement of this concept would be to assess what type of media does the respondent utilized to obtain information for different purposes. No other studies have been published that assessed the association between these variables and total actual genomic knowledge.

Basic genomic knowledge. The same concepts that were associated with total genomic knowledge were the same concepts that were associated with basic genomic knowledge, with the addition of age and perceived need. Age was the only additional personality variable that was associated with basic genomic knowledge and not associated with total genomic knowledge. This may due to the fact that nursing programs are now mandated to include basic genomic competencies within their nursing programs. Therefore, integration of genomics in nursing programs may lead a significantly higher knowledge of basic genomics as compared to nurses who have not had this integration within their initial nursing studies. In addition, perceived need may have been associated with basic genomic knowledge due to the fact that nurses who had a better understanding of basic genomics felt that this innovation is needed within the oncology field because they understand the usefulness of basic genomic testing which can be directly correlated with the usefulness of genomic testing for the guidance of drug therapy.

Similarly, innovativeness, work environment, and communication behavior were not significantly associated with the total basic genomic knowledge score. These relationships are most likely due to similar reasons given in the previous section.

Pharmacogenomic knowledge. The concepts associated with pharmacogenomic knowledge were very similar to the concepts that were associated with

total genomic knowledge. The concepts within the prior conditions were the same. However, the characteristics of the decision-making unit that were associated with total genomic knowledge were the same for pharmacogenomic knowledge except that ruralality had no relation. In addition, the personality variable of previous pharmacogenomic education was related to an increase in pharmacogenomic knowledge, which would be expected. However, ruralality may have not been associated with pharmacogenomic knowledge because of the encompassing lack of pharmacogenomic education and access within both rural and urban settings.

Innovativeness, work environment, perceived need of pharmacogenomic testing, and communication behavior were not significantly associated with the total pharmacogenomic knowledge score. These four concepts may not be associated with total pharmacogenomic knowledge due to similar reasons given for the variable of total genomic knowledge.

Relationships Associated with Attitude (Persuasion)

Attitude (persuasion) is influenced by several factors according to Rogers' (2003). Variables that influence knowledge as well as perceived characteristics of the innovation which include relative advantage, compatibility, complexity, trialability, and observability, influence one's attitude toward the innovation.

Overall attitude. All of the perceived characteristics of the innovation were associated with overall attitude except complexity. Complexity of the innovation may not have been associated with this variable due to lack of an accurate measure of this concept. Development of a different method of measurement for this concept needs to be addressed in order to determine whether this concept is actually not associated with

overall attitude. Complexity should also measure whether the nurse doesn't know if the innovation is complex and therefore, the innovation could be deemed complex with either answer of the belief that this innovation is complex or the uncertainly whether it is complex.

Communication behavior was associated with overall attitude. Utilization of less media sources for information acquisition was associated with a more negative attitude, which could be reveal that the less informed a person is, the more skeptical they are of new ideas. Additionally, a lower perceived need, less experience and knowledge of the innovation were all associated with a more negative overall attitude which could be due to the fact that knowledge acquisition must be obtained prior to persuasion that the innovation is positive.

Innovativeness, work environment, ruralality, and some personality variables were not associated with overall attitude. Work environment and innovativeness may not be associated with attitude due the reasons given for the knowledge variables. Ruralality, age, educational degree, and certification in oncology were more closely associated with the variable of knowledge with Rogers' Diffusion of Innovation Theory. Therefore, these concepts may not be good predictors of attitude.

General attitude. Many of the same concepts that were associated with overall attitude were also associated with general attitude. However, one difference found was that within this sample, nurses with a Bachelor's degree had a more negative general attitude towards pharmacogenomic testing. This finding may be due to the fact that the majority of the sample had a bachelor's degree and small differences could be detected within this group that could not be detected within the other groups.

Innovativeness, work environment, ruralality, some personality variables, and characteristics of the innovations including observability and complexity of the innovation were not associated with general attitude. Observability of the innovation may not be associated with general attitude toward pharmacogenomic testing due to the nurses' preconceived notion of pharmacogenomic testing based on word of mouth rather than actually observing pharmacogenomic testing in practice. The remaining concepts may not be associated with general attitude based on similar reasons given in the previous section.

Attitude specifically related to the field of oncology. Many of the same concepts that were associated with overall attitude were also associated with attitude specifically related to the field of oncology. However, ruralality and work setting was associated with this concept. Nurses within this sample who worked in an urban setting had a more negative attitude. This result could be due to the excessive burden multiple tasks placed on these nurses and this innovation would add another new task to learn. Rural settings may have a more flexible and creative work environment due less stress that urban, academic medical centers often are consumed with. However, a more negative attitude was found among nurses that work in physician's office, which may also be related to a less flexible work environment due to the time constraints with each patient. This also may be the explanation behind why inpatient oncology units have a more negative attitude.

Furthermore, innovativeness, some personality variables, and complexity of the innovation were not associated with attitude specifically related to the field of oncology.

These concepts may not be associated with attitude specifically related to the field of oncology due to similar reasons given in the previous section.

Relationships Associated with Support for Use (Decision)

Support for use is influenced by several factors according to Rogers' (2003). Variables that influence knowledge and attitude also influence support for use according to this theory, including prior conditions, characteristics of the decision-making unit and perceived characteristics of the innovation.

Support for use. Support for use was only associated with perceived basic genomic knowledge. This may be due to the fact that the support for use was only measured by one question. Future analysis should utilize ordinal regression since this concept is an ordinal variable. This analysis may enhance the ability to determine accurate associations within the guiding framework.

Discussion

Several studies have been conducted on the variables that relate to adoption of an innovation by nursing (Bonner & Sando, 2008; Brown, Wickline, Ecoff, & Glaser, 2008; Chang & Lui, 2008; Jenkins, 1999; Jones, 1997; Kitson, 2009; van der Weide & Smits, 2004; Weng, Huang, Huang, & Wang, 2012; Wilcox, 2009). Jenkins (1999) and Weng et al. (2012) only addressed variables that may play a key role in the enhancement of knowledge based on the perceptions of nursing. However Wilcox (2009) revealed that inadequate time, lack of perceived knowledge, and lack of prior experience with the innovation translated to poor knowledge acquisition. These findings coincide with the findings from this study in that the mean knowledge scores for the total genomic, basic genomic and pharmacogenomic testing were predicted by perceived genomic knowledge

and prior experience with the innovation. However Wilcox (2009) did not address certification in nursing, which reveals the reason a different variable was identified that influenced knowledge. Furthermore, perceived need of the innovation was not addressed by Wilcox (2009). However Kitson (2009) revealed that perceived need of the innovation significantly influences the rate of adoption of an innovation. Therefore, this study reveals that perceived need of the innovation first influences knowledge acquisition. In addition, no studies have been conducted that specifically assess variables that influence knowledge of pharmacogenomic testing in nursing; therefore this study adds information to the literature concerning what key factors play a role in the improvement of knowledge among nurses regarding pharmacogenomic testing.

Brown et al. (2008) and Chang & Liu (2008) revealed that flexibility increases diffusion of an innovation. This coincides with the finding that trialability is associated with attitude towards pharmacogenomic testing which leads to diffusion of the innovation. Furthermore, Van der Weide and Smits (2004) concluded that nurses' belief that the innovation is useful for nursing improves innovation of diffusion. This finding is similar to the outcome that an increased relative advantage is associated with a more positive attitude. Based on these results, trialability and relative advantage of the innovation improves diffusion of innovation by enhancing a more positive attitude towards the innovation.

Roederer et al. (2012) revealed that attitude was not significantly different among different educational degrees for pharmacists. However, this dissertation revealed that nurses with a Bachelor's degree had a negative attitude towards pharmacogenomic testing. This variation could be due to the fact that this sample was comprises mainly of

Bachelor-prepared nurses which could have provided significant results based on small differences that could be detected which are not clinically relevant because there was not an adequate distribution of nurses for each degree to determine a true difference in attitude. Furthermore, decreased complexity of the innovation has been shown to improve attitude towards the innovation (Rogers, 2003; Wilcox, 2009). However, this study did not reveal a significant difference between attitudes based on the perceived complexity of the innovation. This finding could be related to the measurement of the variable in which asked whether the innovation was difficult to understand. This measure may be ambiguous and need for revision in future studies. A suggestion for a better measure was given in the previous section on attitude. Moreover, no studies have been conducted that assess the association between attitude of the innovation and the following variables: prior experience with the innovation, communication behavior, ruralality, age, and type of work setting. Therefore, this study enhances the literature in that prior experience, communication behavior, working in an urban area, younger age and type of work setting play a key role in the attitude towards the innovation. These variables should be assessed more carefully in future research.

Furthermore, Jones (2007) revealed that diffusion of innovation was not predicted by innovativeness. This coincides with this study's outcomes that innovativeness did not predict knowledge, attitude, or support for use. In addition, according to Rogers (2003), multiple variables affect the decision (support for use) component. However, this study only indicated one variable as associated with support for use. This finding could be due to the measurement of support for use. Only one question assessed this component.

Therefore, a more accurate analysis of this component of the theory which was discussed should be conducted in future research.

Strengths and Limitations

Strengths. The study sample consisted of 2705 oncology nurses from the state of North Carolina with a 14.3% total response rate. Despite this rather low response rate, based on previously published studies utilizing similar tools to access clinicians' knowledge, attitude and use of pharmacogenomic testing, this study has a much higher response rate. Roederer et al. (2012) and Stanek et al. (2012) only had a response rate of 7.7% and 3%, respectively. Therefore, based on the power analysis conducted prior to the study and this response rate, this study had a sufficient power to generate significant results.

Limitations. Several limitations were found throughout this study. These limitations were divided into separate categories.

***Study tools*.** Respondents who did not receive the questionnaire via email may or may not have access to the Internet. Due to the fact that this questionnaire was completed solely on-line, respondents without Internet access may not have had the opportunity to complete the survey.

Additionally, the Nursing Practice Questionnaire had a low Cronbach's alpha of only 0.58. Therefore, only the individual items were analyzed due to the low reliability of this instrument. Originally, Brett (1987) published a Cronbach's alpha of 0.82 for this instrument. However, this study had multiple innovations that were analyzed. Therefore, this study had more items utilized within the Cronbach's alpha. Ultimately, due to the low reliability, this instrument does not translate well to the application of

pharmacogenomic testing.

Study sample. Only 1230 of the respondents were sent an invitation to take the on-line questionnaire via electronic mail due to the lack of information provided by the North Carolina Board of Nursing. Therefore the remainder of the sample were sent an invitation postcard via mail. There was a possibility that the inconvenience of filling out an on-line survey could have provided the poor response rate.

In addition, several of the sample may have retired from oncology nurses and did not feel that they should participate in the study due to length of time out of the field. They may have felt that this may skew the results.

Furthermore, the list obtained from the North Carolina Board of Nursing also contained nurses interested in the field of oncology rather than solely nurses who work in the oncology field. Therefore, some the population may have self-selected themselves out of this study due to the title indicating the assessment of knowledge and attitudes of oncology nurses. This may also be an explanation of the low response rate.

Finally, this study was only conducted with oncology nurses from North Carolina. Therefore, this may not translate well nationally or internationally among oncology nursing.

Study variables. The study would have benefited from utilizing ordinal regression to evaluate the concept of support for use since this is an ordinal variable. Another method could be utilizing different measures to assess support for use. Rather than asking whether the nurse has ever used pharmacogenomic information in the past, a more effective technique could be also asking to identify what type of pharmacogenomic information they utilize in practice.

Implications for Education

This study revealed that previous basic genomic education lead to an improved perceived knowledge of genomic and pharmacogenomic testing as well an overall higher actual knowledge score on both items. Therefore, genomic and pharmacogenomic education is the key to an improvement in pharmacogenomic knowledge. Most of the respondents felt that they had a poor perceived genomic knowledge and would benefit from continuing education. Therefore, an opportunity for genomic and pharmacogenomic continuing education should be provided for this population. Based on the results, oncology nurses identified CE courses as the most appealing. A formal course that includes basic genomic and pharmacogenomic information as well as pharmacogenomic information specifically related to the oncology field should be developed to help improve perceived knowledge.

Furthermore, integration of genomic and pharmacogenomic information with nursing schools may also improve perceived knowledge of this innovation. Therefore, nursing curriculum should include genomic information throughout each course. In addition, pharmacogenomic testing should be introduced to nursing students before the begin practicing to help improve their understanding and attitude of this innovation.

Finally, nurses with a certification in oncology had a significantly higher perceived and actual genomic and pharmacogenomic testing knowledge. Therefore, future educational endeavors should include the obtainment of such certifications. Provision of incentives for nurses who obtain their nursing certification in oncology may improve the acquisition of these types of certifications.

Implications for Practice

Findings from this study may provide helpful insight for the diffusion of pharmacogenomic testing within the oncology nursing field. Several indicator variables improved knowledge, attitude and support for use of pharmacogenomic testing. Awareness of variables that successfully predict improved knowledge among clinician will help formulate interventional studies that focus on the modifiable variables associated with the improvement in knowledge. Therefore, oncology nurses could potentially enhance their perceived knowledge by attending genomic courses, which is also associated with improved knowledge acquisition. Furthermore, oncology nurse certification has been shown to predict knowledge of the innovation. Therefore, incentives should be provided for oncology nurses to obtain this type of certification due to the improvement in knowledge.

The main variables that significantly indicated a positive attitude towards pharmacogenomic testing were prior experience, relative advantage, trialability, and observability of pharmacogenomic testing. Therefore, easy assessable pharmacogenomic testing information, provision of a list of pharmacogenomic tests available for oncology drugs, and knowledgeable clinicians with prescriptive privileges concerning pharmacogenomic testing should improve oncology nurses' attitudes towards pharmacogenomic testing. Educational courses related to specific pharmacogenomic testing should be made available to oncology nurses to help enhance their overall attitude towards this innovation based on the increased perceived need, relative advantage, and observability of this innovation. Additionally, a more flexible work environment, which

allows for creative workflow will also improve attitude towards innovation according to this study.

In addition, support for use of pharmacogenomic testing significantly improved with a higher perceived genomic knowledge. Therefore, educational courses about pharmacogenomic testing should help improve the support of use of pharmacogenomic testing.

Finally, Van Riper et al. (2012) revealed that practicing nurses had a significantly lower score on average than pharmacists; whereas students in the healthcare field scored significantly higher than all of the practicing disciplines (Van Riper et al., 2012). A reasonable explanation for this outcome could be related to the promotion of widespread integration of genomic information, in which students may be exposed to more genomic education in today's educational settings. Therefore, future studies may reveal an increase of genomic knowledge such as pharmacogenomic testing within the practicing disciplines.

Implications for Future Research

Future research would benefit from an intervention study that includes an educational CE course concerning pharmacogenomic testing related specifically to oncology. The intervention study should include testing of pre- and post- actual knowledge scores and attitude scores. Additionally, key variables associated with the guiding theory should be assessed as well to further enhance the development of the literature.

Moreover, a different analysis for support for use should be conducted in future research utilizing this theory. Development of a support for use scale may also help

improve assessment of multiple variables that are associated with one another according to Rogers' Diffusion of Innovation Theory. Additionally, a different measure for complexity should also be developed to help improve predictiveness of this variable. Currently, this concept was measured as whether pharmacogenomic testing is difficult to understand. This concept could be ambiguous, in which it would benefit from alteration.

The variable of working in an urban setting revealed a higher knowledge score but a more negative attitude towards the innovation. A research study assessing the variables between rural and urban work setting including variation in staff and accessibility of pharmacogenomic testing would be beneficial to identify key factors that may have lead to this outcome.

In addition, other fields may also benefit from this research including cardiology, psychiatry, etc. in order to determine key components of improving the rate of adoption of pharmacogenomic testing within that field. This questionnaire can be modified to fit each type of setting to help identify key variables to improve the diffusion of pharmacogenomic testing specifically related to each field.

Summary

Overall this study indicated several variables that improve oncology nurses' knowledge, attitude and support of use concerning pharmacogenomic testing. Therefore, based on the improvement of knowledge, attitude, and support for use the variables improved perceived genomic education, obtainment of an oncology certification in nursing, and experience with pharmacogenomic testing should ultimately improve the rate of adoption of this innovation.

Implications for education, practice and future research were provided to help enhance the adoption of pharmacogenomic testing among oncology nurses. Limitations of this study were also indicated to help researchers improve the accuracy of future research.

Appendix A:

Data Request Form

North Carolina Board of Nursing – Data Request Form
Request for Prices for Labels, Listings, Diskettes

Please complete the Type of Media, Contact information and Data use and selection specification information below. Please note the Total Fee for the data request will be the STANDARD FEES plus the fee for the Type of Media selected.

STANDARD FEES:
NAMES - $20.00 per 1,000 names up to 10,000; $ .01 per name for each name over 10,000
PROGRAMMING FEE - $35.00
POSTAGE
TAX (where applicable)

Mail the completed form to:
Cindy Thomas
NC Board of Nursing
PO Box 2129
Raleigh, NC 27602
Or fax to: (919) 781-9461

Select the Type of Media desired:

☐ **Paper media**
__ Labels ($4.00 per 1,000 names)
__ Listings ($7.00 minimum for paper)

☐ **Electronic media (Specify format below)**
__ 3 1/2 " Diskettes ($5.00 per diskette)
__ CD ($5.00 per CD)
__ E-mail file. If selected, E-mail address to send to: _____

☐ **Specify the file format for the electronic media selected (diskette, CD or E-mail)**
__ ASCII Text, fixed length
__ ASCII Text, Comma Separated Variable (CSV)
__ Excel Spreadsheet; Specify Version of Excel _____

Contact Information:
Contact Name: _____
Area Code/Phone#: _____ Email: _____
Company Name: _____
Mailing Address:_____
City: _____ State _____ Zip Code: _____
County: _____

Data use and selection specification:
Brief description of how you will use this information:
_____
_____
Data Selection specification – please be as specific as possible: (For example: RN's and/or LPN's in Wake, Durham and Orange counties.)
_____
_____
Fields to be displayed on electronic media: (labels only contain names and addresses.)
_____
_____

Appendix B:

Knowledge, Attitude and Support for Use Questionnaire-Pharmacogenomic Testing (KAQ-PGx) (IS and NPQ-PGx Included)

A. Informed Consent

1. I have read the above information and give my consent to participate in the research study, "Knowledge and attitudes about pharmacogenomic testing among clinicians".

B. Background Information

2. What age best describes you?

   20-29 30-39 40-49 50-59 60-69 70 or greater

3. Which of the following best describes you?

   PhD DNP CNS NP Diploma RN Associate Degree RN BSN LPN Other (please specify)

4. Do you have a certification in oncology nursing?

   Yes No

If pick yes, go to 5; If pick no, go to 6:

5. Which nursing certification do you have? (Choose all that apply)

   OCN CPON CPHON AOCN CBCN AOCNP AOCNS

6. Are you currently practicing as a nurse in the oncology field?

   Yes No

If pick yes, go to 7; If pick no, go to 8:

7. How many years have you been practicing in the oncology field?

   Over 30 Years 25-29 20-24 15-19 10-14 5-9 1-4 Under 1 year

8. How long has it been since you worked as an oncology nurse? (skip to question 12)

   Less than 1 year 1-5 years 6-10 years 11-20 years Greater than 20 years

9. Which type of setting do you work in?

   Rural Urban

10. Do you work at any of these places of employment?

    -Carolinas Medical Center
    -Cone Health
    -Duke Health
    -ECU or Pitt County Memorial Hospital
    -New Hanover Regional Medical Center
    -UNC Healthcare

    Yes No

11. In what type of setting do you work?

    Inpatient Oncology Unit
    Ambulatory Care/Outpatient Center
    Hospice/Palliative Care
    Pain Management Clinic
    Cancer Risk Assessment Center
    Home Health Care
    University/College Setting
    Physician's Office
    Research/Laboratory
    Other (please specify)

12. If you have a specialty in oncology, what is it?

    Pediatric Hematology/Oncology
    Breast Cancer
    Gynecologic Oncology
    Gastrointestinal Cancer
    Head and Neck Cancer
    Lung Cancer
    Genetics
    Radiation Therapy
    Interventional Oncology
    Other (please specify)

C. Individual Responsiveness Scale

People respond to their environment in different ways. The statements below refer to some of the ways people can respond. Please work quickly, there are no right or wrong answers, just record your first impression.

13. My peers often ask me for advice or information.

    1 Strongly Disagree 2 3 4 5 Strongly Agree

14. I enjoy trying new ideas.

    1 Strongly Disagree 2 3 4 5 Strongly Agree

15. I seek out new ways to do things.

    1 Strongly Disagree 2 3 4 5 Strongly Agree

16. I am generally cautious about accepting new ideas.

    1 Strongly Disagree 2 3 4 5 Strongly Agree

17. I frequently improvise methods for solving a problem when an answer is not apparent.

    1 Strongly Disagree 2 3 4 5 Strongly Agree

18. I am suspicious of new inventions and new ways of thinking.

    1 Strongly Disagree 2 3 4 5 Strongly Agree

19. I rarely trust new ideas until I can see whether the vast majority of people around me accept them.

    1 Strongly Disagree 2 3 4 5 Strongly Agree

20. I feel that I am an influential member of my peer group.

    1 Strongly Disagree 2 3 4 5 Strongly Agree

21. I consider myself to be creative and original in my thinking and behavior.

    1 Strongly Disagree 2 3 4 5 Strongly Agree

22. I am aware that I am usually one of the last people in my group to accept something new.

    1 Strongly Disagree 2 3 4 5 Strongly Agree

23. I am an inventive kind of person.

    1 Strongly Disagree 2 3 4 5 Strongly Agree

24. I enjoy taking part in the leadership responsibilities of the group I belong to.

    1 Strongly Disagree 2 3 4 5 Strongly Agree

25. I am reluctant about adopting new ways of doing things until I see them working for people around me.

    1 Strongly Disagree 2 3 4 5 Strongly Agree

26. I find it stimulating to be original in my thinking and behavior.

    1 Strongly Disagree 2 3 4 5 Strongly Agree

27. I tend to feel that the old way of living and doing things is the best way.

    1 Strongly Disagree 2 3 4 5 Strongly Agree

28. I am challenged by ambiguities and unsolved problems.

    1 Strongly Disagree 2 3 4 5 Strongly Agree

29. I must see other people using new innovations before I will consider them.

    1 Strongly Disagree 2 3 4 5 Strongly Agree

30. I am receptive to new ideas.

    1 Strongly Disagree 2 3 4 5 Strongly Agree

31. I am challenged by unanswered questions.

    1 Strongly Disagree 2 3 4 5 Strongly Agree

32. I often find myself skeptical of new ideas.

    1 Strongly Disagree 2 3 4 5 Strongly Agree

D. Background in Genetics/Pharmacogenomics

33. Have you had any of the following types of genetics education? (Select all that apply)

    No, I have had no education in genetics
    Grand Rounds
    Seminar or Workshop
    CE Course

Genetics Course in Graduate School
Undergraduate Genetics Course
Other (please specify)

When was your last genetics course? (If choose any answer other than ‘no’ on question 33)

34. Have you ever attended educational activities related to pharmacogenomic testing?

    Yes No

35. How would you rate your current understanding of genetics?

    Excellent
    Very Good
    Good
    Fair
    Poor

36. How would you rate your current understanding of pharmacogenomic testing?

    Excellent
    Very Good
    Good
    Fair
    Poor

37. Are pharmacogenomic tests available at your place of employment, such as HerceptestTM or AmpliChipTM CYP450 Test?

    Yes No Do Not Know

38. Have you ever cared for a patient who has had a pharmacogenomic test?

    Yes No Do Not Know

39. Have you ever educated a patient about pharmacogenomic testing?

    Yes No

40. Have you ever advocated for your patient to obtain pharmacogenomic testing?

    Yes No

E. Basic Genomics Questions

41. Humans are over 99% identical at the DNA level.

True False Do Not Know

42. Most cells in the human body contain 47 chromosomes.

True False Do Not Know

43. Every time the human body produces a sperm or an egg, approximately 3 billion nucleotides (bases) must be copied and packaged so they can be passed along to future offspring.

True False Do Not Know

44. The nucleotides (bases) in DNA, always match up the same way - Adenine (A) always pairs with the Cytosine (C) and Guanine (G) always pairs with the Thymine (T).

True False Do Not Know

45. A number of genetic conditions, such as Huntington's Disease, are caused by a mutation in a single gene.

True False Do Not Know

F. Questions About Pharmacogenomic Testing

46. Genetic variations can account for as much as 95% of the variability in drug disposition and effects.

True False Do Not Know

47. Genetic determinants of drug response change over a person's lifetime.

True False Do Not Know

48. Subtle differences in a person's genome can have a major impact on how the person responds to medications.

True False Do Not Know

49. A pharmacogenomic test is available for postmenopausal women who are taking or considering taking Tamoxifen to prevent the recurrence of breast cancer.

    True False Do Not Know

50. Pharmacogenomic testing is currently available for most medications.

    True False Do Not Know

The following text is about pharmacogenomic testing. Please read text carefully in order to answer the questions that follow.

The effect of medication varies from person to person, which can be due to the fact that human genetic profiles are not identical. Pharmacogenomic testing is defined as a genetic test that is used to guide a patient's drug therapy based on the individual's genetic make-up. Genetic variations mean that people break down drugs differently. This is the reason that one drug works on some patients, but has no effect on others or is not as effective, and that some patients experience an adverse drug reaction from one drug, while others can tolerate it. Pharmacogenomic testing will enable patients to be treated with medication adapted to their individual genetic profile and thus their own body. This is called personalized medicine because it provides tailor-made treatment adapted to the individual. Pharmacogenomic testing is done through a blood test or cheek swab, which the healthcare provider must carry out before treating the patient. Healthcare providers can see what types of drugs the patient will benefit from before medication is prescribed, and thus the patient will get personalized medicine that is more effective and has fewer adverse drug reactions than the treatment offered today. The test also means that patients with the same disease can be differentiated, so only those who will benefit from the medication should take it. Patients with a different genetic profile can avoid taking medication that won't work for them.

Based on this definition, please answer the remaining questions.

G. Nursing Practice Questionnaire- NPQ-PGx

51. Have you heard of the term pharmacogenomic testing before this questionnaire?

    Yes No

If pick yes, go to 52; If pick no, go to 56:

52. Have you read about pharmacogenomic testing in journal articles, medication labels, etc.?

Yes No

53. Have you observed pharmacogenomic testing in practice?

Yes No

54. Have you acquired information about pharmacogenomic testing from any other source?

Yes No

55. How often do you use pharmacogenomic testing information in your nursing care?

Never Sometimes Always

H. Position About Pharmacogenomic Testing

56. Do you believe that a nurse should use pharmacogenomic testing information in their nursing care?

Yes No Unsure

57. Do you believe that a nurse should educate their patients about the purpose, benefits, limitations and risks of pharmacogenomic testing?

Yes No Unsure

58. Do you believe that pharmacogenomic testing will decrease the cost of developing drugs?

Yes No Unsure

59. Do you believe that pharmacogenomic testing will help to decrease the number of adverse drug reactions?

Yes No Unsure

60. Do you believe that pharmacogenomic testing is difficult to understand?

Yes No Unsure

61. Do you believe that the incorporation of pharmacogenomic testing can be modified for specific settings?

Yes No Unsure

62. How concerned are you that unauthorized persons may gain access to the results of a patient's pharmacogenomic testing?

    1 Not Likely 2 Somewhat Likely 3 Likely 4 Very Likely

63. How concerned are you that your family's healthcare will be affected by your pharmacogenomic testing results?

    1 Not Likely 2 Somewhat Likely 3 Likely 4 Very Likely

64. How concerned are you that pharmacogenomic testing may result in discrimination by employers and /or insurance companies?

    1 Not Concerned 2 Somewhat Concerned 3 Concerned 4 Very Concerned

65. If you have other thoughts or concerns about pharmacogenomic testing, please share them in the box below.

I. Position About Pharmacogenomic Testing to Guide Tamoxifen Therapy

66. Do you believe that oncology represents a particularly promising area for the use of pharmacogenomic approaches.

    Yes No Unsure

67. Do you believe that Tamoxifen efficacy and side effects are in part genetically determined.

    Yes No Unsure

68. Do you believe tumor profiling is useful?

    Yes No Unsure

69. How comfortable would you be having genetic information incorporated into the determination of whether your patient should receive Tamoxifen?

    1 Not Comfortable 2 3 4 Very Comfortable

70. If you were the patient for whom hormonal therapy was being considered, how comfortable would you be having genetic information used to determine whether you should receive Tamoxifen or an alternative agent such as an aromatase inhibitor?

    1 Not Comfortable 2 3 4 Very Comfortable

71. How much do you trust pharmacogenomic tests for determining your patient's treatment?

    1 Not Likely 2 Somewhat Likely 3 Likely 4 Very Likely

72. Do you have prescriptive privileges?

    Yes No

J. Questions for Clinicians with Prescriptive Privileges

73. How likely is it that you would look for pharmacogenomic information about a drug prior to ordering the drug for your patient?

    1 Not Likely 2 Somewhat Likely 3 Likely 4 Very Likely

74. If you were given the results of your patient's pharmacogenomic testing to help guide your prescribing of a particular agent, how comfortable would you be interpreting and using that information on your own?

    1 Not Comfortable 2 3 4 Very Comfortable

75. Have you ordered a pharmacogenomic test before prescribing Tamoxifen?

    Yes No

76. If you have not ordered pharmacogenomic testing before prescribing Tamoxifen, what were your reasons for not ordering it? (Check all that apply)

    I was not aware that this type of testing was available.
    I do not know of or have access to a lab that performs this type of testing.
    I have not seen convincing evidence of the clinical utility of this type of testing.
    Clinical guidelines on how to use the results of this type of testing are lacking.
    Ordering the testing and waiting for results would delay patient treatment.
    This type of testing is not covered by my patient's health insurance plans.
    I do not feel confident about how to interpret and apply the results.
    I am concerned about patient confidentiality and the privacy of genetic data.
    There are too many false positives, false negatives, and/or ambiguous results.
    This type of testing is too expensive.
    Patients are not interested in having this type of testing

K. Future Educational Offerings

77. Which of the following sources have you used at least once within the last week in order to gain information such as current events, educational opportunities, etc.? (Select all that apply).

TV
Radio
Newspaper
Weekly Magazine
Internet
Other Sources (please specify)

78. Would you be interested in learning more about pharmacogenomic testing?

Yes No

79. Which of the following educational offerings about pharmacogenomic testing would you attend? (Select all that apply)

Grand Rounds
Seminar or Lecture
CE Course
AHEC Course
Web-based CE Course
Half-day Conference
All-day Conference
Interdisciplinary
Conference

L. Thank You

Thank you for participating in this study.

If you would like to receive a copy of the correct answers for the True and False questions, email Crissy Dodson at chdodson@email.unc.edu

Appendix C:

Individual Innovativeness Scale (IS)

Directions: People respond to their environment in different ways. The statements below refer to some of the ways people can respond. Please indicate the degree to which each statement applies to you by marking whether you: **Strongly Disagree = 1; Disagree = 2; are Neutral = 3; Agree = 4; Strongly Agree = 5** Please work quickly, there are no right or wrong answers, just record your first impression.

_____ 1. My peers often ask me for advice or information.
_____ 2. I enjoy trying new ideas.
_____ 3. I seek out new ways to do things.
_____ 4. I am generally cautious about accepting new ideas.
_____ 5. I frequently improvise methods for solving a problem when an answer is not apparent.
_____ 6. I am suspicious of new inventions and new ways of thinking.
_____ 7. I rarely trust new ideas until I can see whether the vast majority of people around me accept them.
_____ 8. I feel that I am an influential member of my peer group.
_____ 9. I consider myself to be creative and original in my thinking and behavior.
_____10. I am aware that I am usually one of the last people in my group to accept something new.
_____11. I am an inventive kind of person.
_____12. I enjoy taking part in the leadership responsibilities of the group I belong to.
_____13. I am reluctant about adopting new ways of doing things until I see them working for people around me.
_____14. I find it stimulating to be original in my thinking and behavior.
_____15. I tend to feel that the old way of living and doing things is the best way.
_____16. I am challenged by ambiguities and unsolved problems.
_____17. I must see other people using new innovations before I will consider them.
_____18. I am receptive to new ideas.
_____19. I am challenged by unanswered questions.
_____20. I often find myself skeptical of new ideas.

Scoring:

Step 1: Add the scores for items 4, 6, 7, 10, 13, 15, 17, and 20.
Step 2: Add the scores for items 1, 2, 3, 5, 8, 9, 11, 12, 14, 16, 18, and 19.
Step 3: Complete the following formula: II = 42 + total score for Step 2 - total score for Step 1.
Scores above 80 are classified as Innovators.
Scores between 69 and 80 are classified as Early Adopters.
Scores between 57 and 68 are classified as Early Majority.
Scores between 46 and 56 are classified as Late Majority.
Scores below 46 are classified as Traditionalists.
In general people who score above 68 and considered highly innovative, and people who score below 64 are considered low in innovativeness.

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Appendix D:

Informed Consent

Thank you for your time and attention regarding this research study. The overall purpose of this study is to examine knowledge and attitudes about pharmacogenomic testing (the use of genetic testing to guide a patient's drug therapy) among oncology nurses. I am collecting data from oncology nurses in the state of North Carolina.

Before agreeing to participate in this study, it is pertinent that you are aware of the items that apply to everyone that participates in this research study: (a) involvement in this study is entirely voluntary; (b) there are no risks expected for those who take part in this study and there is no cost to study participants; c) you will not benefit directly from taking part in this study, but knowledge may be gained that might profit others; (d) your involvement is anonymous - so you will not be asked to provide any identifying information; e) all data acquired from this study will be reported as group data in order that no individual can or will be recognized; f) I plan on utilizing the results for my dissertation; g) I plan on presenting the results of this study at local and national conferences; and h) I plan on publishing the results of this study.

Participation in this study involves completing a survey. This survey starts out with some questions about you. Then there are basic genetics questions as well as questions designed to assess what you know and think about pharmacogenomic testing. Finally, there are some questions about future educational opportunities. Completion of the survey should take about 10-20 minutes. Please note that I am interested in your answers even if you have little or no background in genetics or pharmacogenomic testing.

If you have questions or concerns about the study, please contact Crissy Dodson, RN, MSN, Doctoral Candidate, University of North Carolina-Chapel Hill School of Nursing by email (chdodson@email.unc.edu).

All research on human volunteers is reviewed by a committee that works to protect your rights and welfare. If you have questions or concerns about your rights as a research subject you may contact, anonymously if you wish, the Institutional Review Board at 919-966-3113 or by email to IRB_subjects@unc.edu.

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