BSN Students’ Knowledge of Genetics and Genomics

By
KEVIN TROY BESSE

Submitted in partial fulfillment of the requirements for the degree of Doctor of Nursing Practice

Committee Chair: Dr. Mary T. Quinn Griffin
Frances Payne Bolton School of Nursing
CASE WESTERN RESERVE UNIVERSITY

January, 2015
CASE WESTERN RESERVE UNIVERSITY
FRANCES PAYNE BOLTON SCHOOL OF NURSING

We hereby approve the scholarly written project of

Kevin Troy Besse

Committee Chair
Mary T. Quinn Griffin, PhD, RN, FAAN

Committee Member
Joyce J. Fitzpatrick, PhD, RN, FAAN

Committee Member
Dr. June Borazjani, DNP, RN, CPHQ

Date of Defense
October 30, 2014

*We also certify that written approval has been obtained for any proprietary material contained therein.
Abstract

Genetic and genomic knowledge that may help with diagnosis and treatment of many diseases is currently emerging. Nurses must be able to incorporate an understanding of the influence of genetics and genomics into practice. This knowledge should be acquired during preparation for practice. The problem that was investigated by this study is that many nurses lack adequate genetic and genomic knowledge, and without that knowledge, essential genetic competencies cannot be appropriately integrated into practice. Using Everett Rogers’ Diffusion of Innovation Theory as a framework, this descriptive comparative study was an attempt to determine a baseline level of genetic and genomic knowledge in Bachelor of Science in Nursing (BSN) clinical and pre-clinical students; and to determine if there are differences in level of genetic and genomic knowledge between clinical and pre-clinical students. A convenience sample of 844 BSN students enrolled full-time in a four-year curriculum was solicited via email to complete a 31-item test of genetic and genomic knowledge. The response rate was 7.4% (N = 63). A statistically significant difference was noted in scores on the test of genetic knowledge with clinical students performing better than pre-clinical students. With a medium to large effect size (.73), alpha 0.05, beta .20, .80 power was achieved. Item analysis revealed potential weaknesses in the curriculum of one BSN program. Recommendations for future research were detailed.
Copyright (2014) by Kevin Troy Besse, DNP, RN
Acknowledgements

There are several people I would like to acknowledge for helping with my research. First I would like to thank members of my research committee:

Dr. Mary Quinn Griffin – Committee Chair, Frances Payne Bolton School of Nursing, Case Western Reserve University

Dr. Joyce Fitzpatrick – Committee Member, Frances Payne Bolton School of Nursing, Case Western Reserve University

Dr. June Borazjani – Committee Member, Vice President for Clinical Services, Regional Health Systems

Statistician – Gregory C. Graham PhD(c), Frances Payne Bolton School of Nursing, Case Western Reserve University

Colleague mentors at University of Louisiana, Lafayette College of Nursing and Allied Health Professions
Table of Contents

Chapter One: Introduction

Background ........................................................................................................... 1
Purpose of the Study ................................................................................................ 3
Theoretical Framework ............................................................................................ 3
Theoretical Definition of the Main Study Variable ............................................... 7
Significance to Nursing .......................................................................................... 7
Research Questions ............................................................................................... 11

Chapter Two: Literature Review

Nursing Students .................................................................................................... 13
Registered Nurses .................................................................................................. 16
Other Students and Professionals ......................................................................... 19
Conclusions ........................................................................................................... 23

Chapter 3: Methods

Research Design .................................................................................................... 25
Sample and Sampling Methods ............................................................................. 25
Operational Definition of the Main Study Variable .............................................. 27
Instruments ............................................................................................................ 28
High Scored Items on the GLAI ............................................. 50
Limitations .................................................................................. 52
Implications for Nursing Education ............................................ 53
Recommendations for Future Research ................................. 54
Conclusion ................................................................................... 55
List of Figures

Figure 1: Rogers’ Elements of Diffusion of Innovation and Diffusion of Genetic/Genomic Knowledge in Nursing ................................. 7
List of Tables

Table 1: Semester classification in the Department of Nursing .............. 33
Table 2: Exposure to Genetics and Genomics Content .......................... 34
Table 3: Degree of Interest in Genetics ........................................... 35
Table 4: Relevance of Genetics to Future Career ............................... 35
Table 5: Mean Scores on the GLAI .................................................. 39
Table 6: Analysis of Selected Lowest Scored Items on the GLAI .......... 40
Table 7: Analysis of Selected Highest Scored Items on the GLAI ......... 41
Chapter 1

Introduction

In chapter one the background, the purpose of the study and problem statement, the theoretical framework, and the theoretical definition of the main study variable is presented. Chapter one concludes with the significance of the study to nursing and the research questions.

Background

Knowledge of genetics and genomics, and an understanding of the interaction of genes with the environment offer new possibilities for diagnosis and treatment of heart disease, diabetes, asthma, and cancer, and many other conditions (National Human Genome Research Institute [NHGRI], 2012). Genetics refers to the study of a particular gene, while genomics refers to the entire genome of an organism and the environment. Genetics and genomics have implications for complex diseases such as heart disease, cancer, asthma and diabetes because of environmental factors (NHGRI, 2012).

The American Nurses Association (ANA) published essential genetic nursing competencies with contributions from major stakeholders. Briefly, essential genetic nursing competencies are: recognition when one’s own attitudes and values may affect care, advocacy for clients’ access to genetic services, examination of one’s own competency and professional development needs,
incorporation of genetic knowledge into practice, tailoring of genetic information and services to clients’ needs, and advocacy for the rights of clients’ autonomy in genetic decision making (Consensus Panel on Genetic/Genomic Nursing Competencies, 2009). Additionally, the American Association of Colleges of Nursing (AACN) has outlined essential elements of baccalaureate education required to prepare the professional nurse generalist. Genetic and genomic competencies have been integrated into essential elements of preparation for practice as a bachelor’s prepared nurse generalist (American Association of Colleges of Nursing [AACN], 2008). However, Jenkins and Calzone (2007) have noted that integration of genetic content into nursing curricula and practice is inconsistent, potentially limiting nursing students’ knowledge of genetics. More recently, in a survey of nursing integration of genomics into practice, Calzone and colleagues (Calzone et al., 2012) reported nurses’ perception of genomic competency as inadequate. However, most nurses indicated interest in pursuing continuing education in genomics.

Lea and colleagues (Lea, Skirton, Read, & Williams, 2011) pointed out that nursing education has evolved in the 20th century as knowledge and technologies have emerged, giving examples such as electrocardiography and dialysis. In an analogous fashion, knowledge and technology today deals with genetics and genomics. Research has and will continue to yield an improved capacity for screening, testing, diagnosis, and treatment of rare and common illnesses; and nurses should be well versed on basic genetics and genomics, and
their application to health care (Lea et al., 2011). Calzone and colleagues (Calzone et al., 2012) have pointed out that application of emerging knowledge to practice hinges on the preparation on nurses because nurses are the largest contingency of health care providers.

**Purpose of the Study**

The purposes of this study were to determine a baseline level of genetic and genomic knowledge in Bachelor of Science in Nursing (BSN) clinical students; to determine a baseline level of genetic and genomic knowledge in BSN pre-clinical students; and to determine if there are differences in baseline level of genetic and genomic knowledge in BSN clinical and pre-clinical nursing students. The problem that was investigated by this study is that many nurses lack adequate genetic and genomic knowledge, and without that knowledge, essential genetic competencies cannot be appropriately integrated into practice.

**Theoretical Framework**

The guiding theoretical framework for the study was Everett M. Rogers’ Diffusion of Innovations, first published in 1962 (Rogers, 2003). Rogers noted an S-shaped rate of adoption of innovation over time. If individuals’ adoption of innovation is plotted graphically, the resulting distribution would appear as an S. Not all innovations are adopted at the same rate. In the case of rapid adoption the slope of the S appears quite steep; whereas in the case of slow adoption, Rogers describes the slope as relatively flat (Rogers, 2003).
“Diffusion is the process in which an innovation is communicated through certain channels over time among the members of a social system. It is a special type of communication, in that the messages are concerned with new ideas” (Rogers, 2003, p. 5). Four elements identified in every instance of diffusion of innovation include: the innovation, communication channels, time, and the social system involved. These four elements are the major determinants of the slope of the S, or the rate of adoption of innovation.

Rogers describes the innovation as an idea, practice, or object that is perceived as new by the individual or group adopting (Rogers, 2003). Perceived attributes of innovation help to explain the rate of adoption. Relative advantage of an innovation is the degree that an innovation is perceived to be better than what it supersedes. Compatibility is the degree to which an innovation is perceived as consistent with existing values, experiences, and needs of potential adopters. Complexity is the degree to which an innovation is perceived as difficult to adopt. Trialability is the degree to which an innovation is able to be tried on a limited basis. Observability is the degree to which the results of an innovation are visible to others (Rogers, 2003). In the case of genetics knowledge and nursing, the innovation is the application of genetic knowledge in nursing practice.

Communication within the context of diffusion of innovation is the process through which adopters and potential adopters create and share information with one another regarding the new knowledge. The process of this communication involves the innovation; the individual or unit of adoption that has
the knowledge or experience with the innovation and is invested in getting the
innovation spread; another individual or unit of adoption that does not have the
knowledge or experience with the innovation or has limited knowledge and
experience with innovation; and the communication channel connecting the two
units (Rogers, 2003). In the case of genetic knowledge in nursing, the Consensus
Panel may be conceptualized as the first unit of adoption, and practicing nurse
generalists may be conceptualized as the final unit of adoption. However, the line
separating the two is amorphous in that many practicing nurse generalists may
already use genetic knowledge in practice. Communication channels may be
divided into formal and informal. Professional journals, position papers, staff
development activities, formal education, and continuing education activities may
be examples of formal communication channels.

Time, relative to diffusion of innovation addresses the innovation-decision
process which is the process by which an individual or a group progresses from
first learning about the innovation to adoption, the relative earliness or lateness
with which an innovation is adopted by an individual or unit of adoption
compared with other members of the whole system, and the rate of adoption of
innovation in a system (Rogers, 2003).

Whether adopters are individuals or groups within a system,
innovativeness of the adopters influences the rate of adoption. Innovativeness is
the degree to which adopters are early or late in adopting innovation. Adopter
categories regarding innovativeness include: innovators who actively seek
information about new ideas, early majority, late majority, and laggards (Rogers, 2003).

Rogers (2003) describes the social system through which diffusion of innovation occurs as interrelated units engaged in joint problem solving to accomplish a common goal. In the case of genetics knowledge in nursing, practicing nurse generalists comprise the system under scrutiny. He also describes homophily as the degree to which participants in communication are similar, and heterophily as the degree to which participants in communication are different. Similarly homophily and heterophily exist to some degree in members of a system who are communicating about innovation. Homophily speeds diffusion as heterophily impairs diffusion of innovation (Rogers, 2003). Unquestionably there is a degree of homophily/heterophily among the members of the system comprised of practicing nurse generalists; however, measurement of such is beyond the scope of this project.

Diffusion of innovation can be used to describe adoption or lack of adoption of genetic competencies in professional nursing. Nursing education is one channel of communication used for diffusion of innovation throughout the profession. Establishing content related to genetics competencies is one step towards adoption of innovation in the profession. The results of this study may provide a baseline level of genetics knowledge in both BSN preclinical and clinical students, which could be valuable in curriculum planning. This study fits into Rogers’ framework in the first stage of diffusion.
<table>
<thead>
<tr>
<th>Element of Diffusion of Innovation</th>
<th>Diffusion of Genetic/Genomic Knowledge in Nursing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Innovation</td>
<td>Emerging Genetic/Genomic Knowledge</td>
</tr>
<tr>
<td>2 Communication</td>
<td>Position Papers / Competencies Delineated</td>
</tr>
<tr>
<td>3 Time</td>
<td>Work of advocates, early adopters, champions, educators, staff developers</td>
</tr>
<tr>
<td>4 Social System</td>
<td>Broad adoption by the community (system) of practicing nurse generalists</td>
</tr>
</tbody>
</table>

*Figure 1*

Rogers’ Elements of Diffusion of Innovation and Diffusion of Genetic/Genomic Knowledge in Nursing

**Theoretical Definition of the Main Study Variable**

The major concept of this study was level of genetic and genomic knowledge. The level of genetic and genomic knowledge is: sufficient knowledge and appreciation of genetics and genomics to enable the nurse to participate in social decision making regarding genetic and genomic issues, and to assist clients to participate in informed decision making. This definition was informed by the Bowling and colleagues’ (Bowling, Acra et al., 2008) definition of genetic literacy.

**Significance to Nursing**
Jenkins and Calzone (2007) have noted that incorporation of genetic and genomic content into nursing curricula and practice is inconsistent. Inclusion of content into licensure and certification exams is also inconsistent. Many nurses do not appreciate the importance of genetic and genomic knowledge to nursing and see it as the domain of a subspecialty (Jenkins and Calzone, 2007). Thus many nurses have a lack of genetic and genomic knowledge, and without the knowledge, essential competencies cannot be appropriately integrated into practice.

Genetic and genomic knowledge that may help with diagnosis and treatment of many diseases is currently emerging. Nurses must be able to assess patients, advocate for patients, teach patients, and refer patients while incorporating an understanding of the influence of genetics and genomics. The information required should be acquired during academic preparation for professional practice. By assessing, and then increasing students’ level of knowledge, when they begin practice their use of genetic and genomic knowledge will increase, and their patients will experience less suffering and dying. This study makes a contribution by adding to the body of knowledge by establishing a baseline level of genetics and genomic knowledge in BSN preclinical and clinical students.

The findings of this study are important to the public’s health in that they may inform preparation of practicing nurses. The Institute of Medicine (IOM) recommendation is that all registered nurses in the United States function to the
full extent of their educational preparation (Committee on the Robert Wood
Johnson Foundation Initiative on the Future of Nursing, at the Institute of
Medicine, 2011). The recommendation regarding educational preparation is that
nurses should achieve higher levels of education and training through an
improved education system that promotes seamless academic progression
(Committee on the Robert Wood Johnson Foundation Initiative on the Future of
Nursing, at the Institute of Medicine, 2011).

The American Association of Colleges of Nursing (AACN) periodically
updates essential elements for preparation of baccalaureate nurses. These
recommendations reflect recommendations of key stakeholders. Most recently
updated in 2008, the first essential of baccalaureate education for professional
nursing practice of the registered nurse is a liberal education including life
sciences such as biology and genetics. The bachelor’s prepared nurse is prepared
to practice with individuals, families, groups, communities and populations across
the lifespan and across the continuum of health. This nurse understands and
respects the variation of care, the increased complexity, and the increased use of
health care resources. Scientific knowledge such as knowledge of genetics and
genomics has and will continue to impact prevention, diagnosis, and treatment of
disease. The bachelor’s prepared registered nurse is committed to lifelong
learning. Genetics and genomics are examples of areas where knowledge is being
generated, demanding the nurse participates in continuous self-evaluation and
information seeking (AACN, 2008).
The study also addresses The American Nurses Association (ANA) objectives. The ANA published essential competencies established by a consensus panel of stakeholder organizations (Consensus Panel on Genetic/Genomic Nursing Competencies, 2009). Professional responsibilities of the registered nurse are recognizing when one’s own attitudes and values may affect care, advocating for clients’ access to genetic services, examining of one’s own competency and professional development needs, incorporating genetic knowledge into practice, tailoring of genetic information and services to clients’ needs, and advocating for the rights of clients’ autonomy in genetic decision making (Consensus Panel on Genetic/Genomic Nursing Competencies, 2009).

Considering AACN (2008) essentials, competencies outlined by the Consensus Panel on Genetic/Genomic Nursing Competencies (2009), and the IOM (Committee on the Robert Wood Johnson Foundation Initiative on the Future of Nursing, at the Institute of Medicine, 2011) recommendations; preparation for professional nursing practice should include genetic and genomic knowledge. Findings from this study will add to the body of knowledge regarding BSN preparation and level of genetic and genomic knowledge. Results may spur examination of curricula, or inform curriculum change. Results may prove useful in creation of strategies aimed at increasing BSN students’ level of genetic and genomic knowledge, thus increasing practicing nurses’ level of genetic and genomic knowledge, and use of that knowledge in practice.
**Research Questions**

1. What is the baseline level of genetic and genomic knowledge in BSN clinical students?
2. What is the baseline level of genetic and genomic knowledge in BSN pre-clinical students?
3. Is there a difference in the baseline level of genetic and genomic knowledge in BSN clinical and pre-clinical students?
Chapter 2

Literature Review

Chapter two contains a brief description of studies regarding genetic and genomic knowledge among both undergraduate and graduate nursing students, practicing registered nurses, other students and professionals. The reviewed studies revealed strategies aimed at integration of genetic and genomic content into health care preparation courses, and attempts at measuring genetic and genomic knowledge, and the tools utilized. Gaps in the literature were identified.

Databases utilized were: Academic Search Complete, CINAHL, Cochrane Library, Medline, ProQuest Nursing and Allied Health Source, and PubMed. Searching years 2000 to 2014, search terms: genetic knowledge and nursing students, genomic knowledge and nursing students, knowledge of genetics and nursing students, knowledge of genomics and nursing students, and nursing and genetics were used. The search was further limited to peer-reviewed articles in scholarly journals. Fifty-four articles were retrieved and reviewed. Articles that discussed either, strategies aimed at increasing students’ or nurses’ knowledge of genetics, or genetics and genomics; measuring students’ or nurses’ knowledge of genetics, or genetics and genomics; or providing background information were included. Nineteen articles supplied quantitative information with descriptions of strategies aimed at increasing genetic or genomic knowledge, or measuring genetic or genomic knowledge were used.
Nursing Students

In this section studies involving undergraduate nursing students were reviewed. There have been few widely published needs assessments regarding level of genetic or genomic knowledge in BSN students. The first study reviewed reveals an intervention involving nursing and dietetic students.

Cragun, Couch, Prows, Warren, and Christianson (2005) used a quasi-experimental pretest/posttest design to evaluate the effect of a short-term genetics educational intervention on nursing and dietetic students’ level of genetics knowledge and confidence in performing genetic-related services, and attitudes about genetic-related topics and educational methods used for the intervention. A total of 87 nursing students and 21 dietetic students participated for participation rates of 87% and 88% respectively. A multifocal instrument was developed to measure level of genetic knowledge, confidence in ability to provide genetics services, likelihood of use of genetic services, ratings of importance of genetics to future careers, and attitudes towards methods aimed at integrating genetics into curricula. Paired t-tests demonstrated a significant increase in level of genetics knowledge after participation in the genetics teaching intervention. Cragun and colleagues’ description lends support for a short term genetics education intervention (Cragun et al. 2005).

Another study aimed at presenting genetics and genomics content and measuring genetic and genomic knowledge was reviewed. Tavernier (2009) described enhancing student appreciation of family genetics by using a genogram.
A total of 107 junior level nursing students participated in a genogram assignment in which they used a qualitative ethnographic approach to explore their own family genetic history. Using a Likert scale, students rated the assignment according to their appreciation of its value as a worthwhile experience. There is a major limitation in Tavernier’s study in that the tool used only measures student appreciation and not necessarily knowledge of genetics. Though limited, Tavernier’s description does lend support to junior level nursing students possessing appreciation of genetics (Tavernier, 2009).

Dodson and Lewallen (2010) worked with undergraduate nursing students. Permission was obtained to administer a Genetic Needs Assessment Survey which was administered to 275 students during class time. In their study, in response to questions related to participants’ perceived knowledge of genetic conditions and terminology, participants could answer, “None”, “minimal”, “some”, or “high”, indicating their perceived level of knowledge about the subject. Most of the participants reported “some” or “high” knowledge regarding genetics terms. However reports of perceived knowledge of specific conditions were quite varied. For example, most of the respondents reported none or minimal knowledge of hemochromatosis, but some knowledge of colon cancer. For all genetic terms and conditions, less than half of the respondents reported high level of knowledge.

Overall mean scores increased from freshman to senior levels (Dodson & Lewallen, 2010). For questions related to clinical comfort level with genetics, respondents could select between four choices, “definitely not”, “probably not,
“probably yes”, or “definitely yes”. Ninety-six percent of participants reported feeling comfortable with finding information on the internet, but only 61% reported feeling comfortable with speaking to patients or patients’ family members about genetics. Sixty five percent reported feeling comfortable drawing a pedigree, but only 35% reported feeling comfortable predicting outcomes of a pedigree (Dodson & Lewallen, 2010).

Daack-Hirsch and colleagues (Daack-Hirsch, Perkhounkova, Furukawa, & Ramirez, 2012) assessed genetic and genomic literacy using the Genetic Literacy Assessment Inventory (GLAI) developed by Bowling and colleagues (Bowling, Acra et al., 2008). In part, this was an attempt to transition from using self-reported perceived knowledge about genetics, and comfort level with genetics content, to genetic literacy. Ninety-six nursing faculty members and 410 undergraduate nursing students were invited to participate via email with a URL for accessing the survey. With a 30% response rate from faculty and a 20% response rate from students, scores were presented as a percent. Faculty answered an average of 76% of the questions correctly and students answered an average of 73% of the questions correctly. There was no statistically significant difference in scores between the two groups. This may be the first study using the GLAI with nursing faculty and nursing students. Although the 20% response rate from students were a concern, considering the study was to assess feasibility of using the GLAI for assessment of genetic literacy, the instrument was found to be a
useful instrument in that the questions are straightforward, and overall the instrument is easy to administer and interpret.

**Registered Nurses**

Maradiegue and colleagues (Maradiegue, Edwards, Seibert, Macri, & Sitzer, 2005) used a 109-item survey to measure perceived knowledge of medical genetics, clinical comfort level with genetics, previous training in genetics, and methods of integrating genetics into the curriculum in advanced practice nursing students. Class time was allocated and 46 graduate level advanced practice nursing students enrolled at two universities participated. For questions related to participants’ perceived knowledge of genetic conditions and terminology, participants were asked to answer, “None”, “minimal”, “some”, or “high”, indicating their perceived level of knowledge about the subject. For almost all of the genetic terms, more of the respondents reported some knowledge, rather than none, minimal, or high knowledge. Responses for perceived knowledge for specific conditions varied; however, disappointing was the fact that fewer respondents reported a high level of knowledge of any of the genetic conditions listed. Overall, the graduate level nursing students felt uncomfortable integrating genetics into their practice (Maradiegue et al., 2005).

Using a shortened version of the medical genetics survey described and used by Maradiegue and colleagues (Maradiegue et al., 2005) Edwards and colleagues (Edwards, Maradiegue, Siebert, Macri, and Sitzer, 2006) surveyed nurse practitioner faculty. Forty of 440 attendees at a national conference of nurse
practitioner faculty participated. This was to determine faculty member’s perception of their knowledge of medical genetics concepts, their perceptions regarding the importance of integrating genetics content into nurse practitioner education and barriers to doing so. Additionally it was an attempt to determine what specific content was already integrated into nurse practitioner curricula, prior education of faculty in genetics content, and faculty comfort level with teaching content? A total of 87% of respondents reported their perceived knowledge of medical genetics as low to moderate. More (95%) felt the content was important in nurse practitioner preparation. Most respondents (72.5%) reported that genetics content was integrated into specific courses in their curriculum. Approximately half of the respondents felt comfortable teaching basic Mendelian genetics, but only 40% felt comfortable teaching a three-generation family pedigree. Further research was recommended to nurse practitioner programs, to get a clearer picture of genetics content in nurse practitioner curricula (Edwards, et al., 2006).

In a five-year follow up and replication of the Edwards and colleagues (Edwards et al., 2006) study, Maradiegue, Edwards, and Seibert (2013) measured level of genetic and genomic knowledge, perception, and integration of genetics and genomics content among advanced practice nursing faculty. The study took place at a national advanced practice registered nurse faculty conference in 2010. Eighty-five (17.7%) of approximately 480 conference attendees participated. In comparison to the original study (Edwards et al., 2006) there was a decrease in
faculty members who self-reported moderate genetic knowledge (62.5% in 2005 and 52.0% in 2010), and an increase in faculty members who reported high/very high genetic knowledge (5.0% in 2005 and 15% in 2010). Respondents reporting very low/low levels of genetic knowledge were similar (32.5% in 2005 and 33.0% in 2010). Greater than 42% surveyed self-reported comfort with teaching basic genetic concepts. Overall, improvements were noted, however many were still uncomfortable with teaching basic genetic concepts and conditions (Maradiegue et al., 2013).

In 2012, Calzone and colleagues (Calzone et al., 2012) reported that nurses perceived their competency with genetics to be inadequate, and the use of a family history is not routine. Using a convenience sample of nurses employed by the National Institute of Health (NIH) a 43-item survey was sent via email 839 nurses to assess attitudes, practices, receptivity, confidence, and competence of nurses’ integration of genomics into nursing practice. The sample included 56% BSN graduates, 26 with master’s degrees in nursing, and three percent prepared at the doctoral level. Twenty two percent were researchers, eight percent case managers, and seven percent nurse practitioners. Ninety percent reported that some portion of their time included seeing patients in some capacity. The response rate was 28%, (239 nurses) and respondents reported that genomic competency was inadequate, and family history was not routinely utilized in caring for patients. However, most nurses reported an interest in pursuing more education in genomics (Calzone et al., 2012).
Other Students and Professionals

LeLacheur, Straker, and Macri (2007) evaluated a genetics curriculum for physician assistant students. The purpose of the study was to evaluate the effectiveness of a focused genetics curriculum consisting of lecture, a genogram project, and a standardized patient encounter. Utilizing a pretest/posttest design with no control group, a paired t-test was used to determine change in level of genetic knowledge and perceived knowledge of genetics. Thirty of 50 eligible students signed consent, and 24 of the 30 students who signed consent actually completed both the pretest and posttest with appropriate coding needed to match pre- and posttest results for analysis. Results demonstrated a statistically significant gain in knowledge and in perceived knowledge. The contribution of this study is limited because it consisted of a small sample. However LeLacheur and colleague described an attempt to document effectiveness of a multimodal genetics teaching intervention. The activity lends support for using a combination of strategies to increase level of knowledge of a complex topic (LeLacheur et al. 2007).

Bowling and colleagues (Bowling, Acra et al., 2008) described development of an instrument used to evaluate genetics literacy in undergraduate students. The resulting Genetic Literacy Assessment Instrument (GLAI) is a 31-multiple choice item instrument which covers six major genetics topics which are further divided into 17 more specific genetics sub-concepts.
The initial GLAI contained a pool of 56 questions, some newly created and some from various academic sources. Content validity and discriminant validity were established first via review by genetics professionals, instructors, and graduate students. For each item the reviewers were asked three questions: Does the question test the concept? Does the question test genetics literacy? Is the question a quality question? Focus groups were then held with college freshmen from various disciplines to assist in modifying wording of questions. Finally a pilot study with 11 self-selected students in a biology course for non-biology majors was conducted for revision of questions. The final version of the GLAI contains 31 items covering six major genetics concepts which are further divided into 17 sub-concepts. The five major topics are: 1) nature of genetic material, 2) transmission, 3) gene expression, 4) gene regulation, 5) evolution, and 6) genetics and society.

To establish the GLAI’s ability to discriminate between groups, one group of graduate students and two groups of undergraduate students were recruited. The significantly higher scores of graduate students and the lack of significant difference between the two undergraduate groups speak to the validity of the GLIA since results were within expectations (Bowling, Acra et al., 2008).

The GLIA underwent two tests of reliability – stability and internal reliability. Test-retest scores revealed a Pearson correlation of 68% with seven weeks between test and retest demonstrating stability. Cronbach’s alpha was used to test for internal reliability, referring to the relationship between each item and
the participant’s overall score. Two sets of scores were analyzed. Reliability estimates were 0.995 (N=395), and 0.997 (N=330) demonstrating internal reliability (Bowling, Acra et al., 2008).

In 2008, Bowling and colleagues (Bowling, Huether et al., 2008) first described use of the GLAI to assess effects of undergraduate biology and genetics courses on students’ knowledge of genetics. A total of 287 students from six courses (five introductory biology courses and one introductory genetics course) from five different institutions completed a pre-course, and a post-course assessment using the GLAI. Using a one-tailed paired t-test, the study revealed statistically significant gains from the courses taken when GLAI scores were analyzed (Bowling, Huether et al., 2008).

McCarthy, Pufulete, and Whelan (2008) looked at knowledge of genetics and nutritional genomics among dietitians practicing in the United Kingdom. Six hundred questionnaires were mailed and 389 (64.8%) useable questionnaires were returned. The largest group of respondents reported having had a university education or a traditional dietetic diploma, and having had some genetic component to their university education. Total knowledge scores were higher in those dietitians with higher qualifications. Knowledge scores were also higher in those with more university genetics content. Scores were higher in those who reported reading literature or attending a conference relating to genetics or nutritional genomics within the past year.
Morren and colleagues (Morren, Rijken, Baanders, & Bensing, 2007) developed an 11 item Perceived Genetic Knowledge Scale (PGKS) and a 13-item Attitudes towards Genetic Testing Scale. Both were used by Calsbeek and colleagues (Calsbeek, Morren, Bensing, & Rijken, 2007) who added a 16-item Factual Genetic Knowledge Scale (GKS). Both studies assessed knowledge among patients with chronic health conditions such as asthma, diabetes mellitus, and cardiovascular disease.

One quasi-experimental study focused on comparing strategies for teaching genetics content to high school students. Starbek, Starcic Erjavec, and Peklaj (2010) compared instruction modes in teaching genetics. Four classes in four high schools in Ljubljana, Slovenia were included and randomly assigned to one of the four experimental conditions employing a quasi-experimental design. Students in group one were taught using traditional lecture format; students in group two were taught only by reading texts; group three students were taught through multimedia that integrated two computer animations, and group four students were taught by text supplemented with illustrations. Students received a pretest and two posttests, one immediately after intervention, and one five weeks after intervention. Groups three and four (multimedia that integrated two computer animations, and text supplemented with illustrations) acquired more knowledge, and demonstrated better retention of acquired knowledge and improved comprehension. The instrument used to measure knowledge was not reported or described.
Bates and colleagues (Bates, Quinn Griffin, Killion, & Fitzpatrick, 2011) described measuring knowledge and attitudes towards genetic testing, and willingness to participate in genetic testing in African-American males. Their sample consisted of 104 African-American males from 19 to 79 years of age, attending a district meeting of a national African-American fraternity. Members of the fraternity join at either the graduate or undergraduate level. Graduate members must have an undergraduate degree from an accredited university. Undergraduate members must have at least a 2.5 grade point average (in a 4.0 system) and have completed at least 36 semester hours. A survey packet was provided with all surveys including the perceived knowledge of genetic testing survey, attitudes toward genetic testing, and willingness to participate in genetic testing. The instrument used was developed by Morren and colleagues (Morren et al., 2007). Overall perceived knowledge of genetic testing, which included medical possibilities with genetic testing and social consequences of genetic testing, was low. However, participants reported a favorable attitude toward genetic testing. Participants also reported willingness to participate in genetic testing.

Conclusions

Strategies aimed at measuring and increasing knowledge of genetics and genomics among undergraduate nursing students, dietetic students, graduate nursing students, graduate nursing faculty, and others have been published (Bates, et al., 2011; Cragun et al., 2005; Dodson & Lewallen, 2010; Edwards et al., 2006;
Maradiegue et al., 2005; Maradiegue et al., 2013). In 2012 Calzone and colleagues’ (Calzone et al., 2012) research with nurses revealed that nurses still self-reported their competency with genetics was inadequate, and that taking a family history was not routine. LeLacheur and colleagues’ work (LeLacheur et al. 2007) with physician assistant students, although small, did lend support for using a multimodal approach for teaching genetics and genomics. Using a multimodal approach is also supported by the quasi-experimental study with high school students by Starbek and colleagues (Starbek et al., 2010). McCarthy et al. (2008) discussed knowledge of genetics and nutritional genomics among dietitians in the United Kingdom, linking higher levels of education including having taken a course in genetics at the university level with higher knowledge. Studies that have produced instruments (Bowling, Acra et al., 2008; Bowling, Huether et al., 2008; Morren et al., 2007) have been useful in assessing the lay public and nursing students.

More studies are needed, especially at the BSN level if academic preparation is to be influenced. The findings from this study will help to fill that gap. Results may inform curriculum change aimed at increasing BSN students’ level of genetic and genomic knowledge, thus increasing practicing nurses’ level of genetic and genomic knowledge, and use of genetics and genomics in practice.
Chapter 3

Research Methods

In chapter three the study design, sample and sampling methods are described. Details of the operational definition of the main study variable, the instruments, and procedure are provided. Strategies for statistical analysis, data management, and the protection of human subjects are detailed.

Design

The research design for this study was descriptive comparative. Variables were not manipulated and there was no intervention involved.

Sample and Sampling Methods

The sample consisted of students who have declared nursing as their major, and were enrolled full time, which is greater than or equal to 12 credit hours at the University of Louisiana at Lafayette, College of Nursing and Allied Health Professions. At the time of the study there were 848 students who have declared nursing as their major. The curriculum for the Baccalaureate of Science Degree in Nursing (BSN) consists of eight semesters divided into freshman, sophomore, junior, and senior years. Students are admitted to the college as beginning freshmen students and start taking nursing courses. However there is no clinical component to the curriculum until the second semester of the sophomore year which is typically the student’s third semester in the college. At the time of the study there were 510 pre-clinical nursing students. Some of these 510 pre-clinical students may be considered freshman, sophomore, junior or senior level
students but have not enrolled in a clinical course. This occurs because there are transfer students from other disciplines or other universities. Of the 510 pre-clinical students some may have taken the required biology where they would have been exposed to genetic and genomic content. At the time of the study there were 107 senior level clinical nursing students, 121 junior level clinical nursing students, and 110 sophomore level students who were enrolled in the first clinical which takes place during the second semester, sophomore year. All clinical students had taken the required biology course where they would have been exposed to genetic and genomic content (University of Louisiana at Lafayette College of Nursing and Allied Health Professions, 2011).

A power analysis was conducted to determine the sample size for this study. An a priori power analysis indicated that, with alpha set at .05, beta set at .20 with a medium effect size (.50) to achieve a .80 power, a total of 128 respondents would be required.

Students at the University of Louisiana at Lafayette, College of Nursing and Allied Health Professions take Biology 110, Fundamentals of Biology I as a pre-requisite course for other required biology courses (Biology 220, Survey of Human Anatomy and Physiology and Biology 261, General Microbiology). All biology courses must be completed prior to registration for Nursing 208, Fundamentals of Caregiving which is the first clinical course and commonly entered the second semester of the sophomore year (University of Louisiana at Lafayette College of Nursing and Allied Health Professions, 2011). It is in the
first biology course where students learn cell structure and function, Mendelian genetics, general physiology, and reproduction (University of Louisiana at Lafayette, 2011). All other genetic and genomic content appears in courses where content is relevant.

Inclusion criteria included, being enrolled full time, which is greater than or equal to 12 credit hours, in the pre-licensure BSN program of studies. Students who are already licensed as registered nurses were excluded. Students enrolled at less than 12 credit hours were also excluded.

Previous studies with similar groups were reviewed to estimate response rate to an electronic survey used for data collection. Dodson’s study with undergraduate nursing students was conducted during class time; therefore information cannot be extrapolated. Calzone and colleagues’ study with nurses employed by the National institute of health (Calzone et al., 2012) utilized internet technology to collect data. Part of the purpose of the study was to determine feasibility of using electronic technology to collect data. Calzone and colleagues reported a 28% response rate.

**Operational Definition of the Main Study Variable**

The main variable of focus was level of genetic and genomic knowledge. The operational definition level of genetic knowledge was the total score on the Genetic Literacy Assessment Instrument (GLAI).
Instruments

The primary tool to be used for assessing level of genetics knowledge was the Genetics Literacy Assessment Instrument (GLAI) developed by Bethany Vice Bowling of the Department of Biological Sciences, Northern Kentucky University, and colleagues (Bowling, Acra et al., 2008). The GLAI consists of 31 multiple choice questions. Questions address six basic genetics and genomics concepts which are further divided into 17 sub-concepts. Each question has one answer; therefore each question is either correct or incorrect. The total score is a whole number equal to the number of correct responses. The Cronbach’s alpha for original tests of reliability for the GLAI was 0.99 (Bowling, Acra et al., 2008).

The demographic and background data collection questionnaire used for this research project is a tool which was created by the principal investigator. The questionnaire consists of basic demographic data such as gender, and academic classification (first semester freshman through second semester senior). There are six questions with yes/no answers asking about potential prior exposure to genetics and genomics content. There are two questions regarding the student’s appreciation of genetics and genomics as relevant to their career. These two questions are to be answered with a Likert-type scale.

Procedure

Institutional Review Board (IRB) approval was first obtained from University of Louisiana at Lafayette, and then Case Western Reserve University. Then, pre-licensure BSN students at University of Louisiana at Lafayette,
College of Nursing and Allied Health Professions were contacted by email sent via the Office of Student Services to all students at one time. Purposes of the study were explained. Complete anonymity was assured. Students were assured that no connection can be made between their willingness or unwillingness to participate and their identity, or to their responses and their identity. Imbedded in the email was a link to Survey Monkey. The link led to a page with questions to ascertain students met inclusion criteria. To confirm, students were asked to proceed to the next screen. The second screen contained the consent form. Again, students were assured of anonymity and that no connection can be made between their identity and their willingness or unwillingness to participate, or to their responses and their identity. The estimated time to take the survey was 15 minutes. Students were asked to complete the entire survey including demographic and background data. Potential participants were asked to read the consent form carefully, and if they agreed to participate in the study click “submit”. The next screen led to the survey questions on genetics and genomics, and then demographic and background data. After one week students received a reminder email, at the end of the second week they received a second reminder. The survey remained open for three weeks. Only one submission for each student was allowed.

**Statistical Analysis and Data Management**

On the day after the survey was closed to students, scores were retrieved from Survey Monkey and entered into a statistical program for analysis. IBM
SPSS version 22 was used for data analysis. First, responses were reviewed for inclusion criteria and missing data.

Questions four through thirty-four of the survey comprised the test of genetic and genomic knowledge, the Genetic Literacy Assessment Instrument (GLAI). The GLAI consists of 31 multiple choice questions. The score is the number of questions answered correctly. The 31 items were reviewed for missing and multiple responses. The decision was made to mark as incorrect any item that did not contain a response, or any item that contained multiple responses. A variable was created in the SPSS data set for each respondent’s score on the test of genetic knowledge. To evaluate the reliability of the instrument, scores on the GLAI were analyzed for a Cronbach’s alpha coefficient. Then a total mean score on the GLAI was calculated for BSN clinical students and BSN pre-clinical students. An independent t-test was calculated to assess differences between the two groups. To examine specific items on the GLAI, a frequency table was produced for clinical students and for pre-clinical students, revealing the number and percent of correct responses for each item.

Responses to questions comprising the demographic and background data information portion of the survey were examined and tallied. Frequencies and percentages were recorded using SPSS. Data were stored on an encrypted laptop computer which was stored in a locked file cabinet.
Protection of Human Subjects

Several steps were taken to maintain protection of human subjects involved in this research. Institutional Review Board (IRB) approval was obtained at the University of Louisiana at Lafayette where the research was conducted, and at Case Western Reserve University. A waiver of written consent was requested and obtained from the IRB. All data were stored on a password protected computer and viewed only by the primary researcher, and a statistician. All data will be destroyed after three years.

Participants were given an explanation of the procedure for completing the survey questions, and a description of potential benefits to be obtained from results. Participants were assured that participation is voluntary and that they are free to withdraw from participation any time simply by ceasing to answer questions on the survey or by failing to submit results electronically. Assurances of anonymity were given. The electronic survey tool prohibited the researcher or any other party to connect participation or non-participation with any identifying information. Assurances were given that there are no potential consequences for refusing to participate or for withdrawing from the research.
Chapter 4

Results

In chapter four, results of the study are presented. This chapter includes response rates, sample characteristics, and instrument reliability. The results for each question are provided in detail.

Response Rate

The overall response rate for this study was 7.4% (N = 63). A total of 848 surveys were distributed to students who have declared nursing as their major at University of Louisiana at Lafayette, College of Nursing and Allied Health Professions. A total of 69 surveys were retrieved from Survey Monkey. The first three questions of the survey comprised criteria for inclusion. Of the 69 surveys retrieved, six were omitted because they were submitted by students who were not full time students. Of the 848 students sent surveys, 510 (60%) were enrolled in pre-clinical courses and 338 (40%) were enrolled in clinical courses which includes second-semester sophomore students (n = 110), junior students (n = 121), and senior students (n = 107). Twenty-two of the 510 pre-clinical students (4.3%) responded to the survey, and 41 of the 338 clinical students (12.1%) responded. The response rate per class standing was 4.3% (n = 22) for pre-clinical students, and 12.1% (n = 41) for clinical students which can be sub-divided into 8.2% (n = 9) for sophomores, 17.4% (n = 21) for juniors, and 10.3% (n = 11) for seniors.
Sample Characteristics

Eight (12.7%) of the respondents were male, 54 (85.7%) were female. One respondent did not provide gender. Of the 63 surveys returned, 22 (34.9%) were from pre-clinical students, including freshmen and first-semester sophomores. A total of 41 (65.1%) were clinical students, sub-divided into nine (14.3%) second-semester sophomores; 16 (25.4%) first-semester were junior level students; five (7.9%) second-semester junior level students; two (3.2%) first-semester senior students; and nine (14.3%) second-semester senior students. These results are displayed in Table 1.

Table 1

*Semester classification in the Department of Nursing*

<table>
<thead>
<tr>
<th>Response</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not enrolled in clinical</td>
<td>22</td>
<td>34.9</td>
</tr>
<tr>
<td>Second semester sophomore</td>
<td>9</td>
<td>14.3</td>
</tr>
<tr>
<td>First semester junior</td>
<td>16</td>
<td>25.4</td>
</tr>
<tr>
<td>Second semester junior</td>
<td>5</td>
<td>7.9</td>
</tr>
<tr>
<td>First semester senior</td>
<td>2</td>
<td>3.2</td>
</tr>
<tr>
<td>Second semester senior</td>
<td>9</td>
<td>14.3</td>
</tr>
</tbody>
</table>

In response to the question, “Prior to university studies have you taken courses that included genetics content, 52.4% (n = 33) responded “yes”, and 46% (n = 29) responded “no”. One student did not give a response. In response to the
question, “Have you taken a university level course in genetics, 6.3% (n = 4) responded “Yes”, and 93.7% (n = 63) responded, “No”. In response to the question, “Have you taken a university level biology course”, 95.2% (n = 60) responded, “Yes”, and 4.8% (n = 3) responded, “No”. The results are displayed in Table 2.

**Exposure to Genetics and Genomics Content**

<table>
<thead>
<tr>
<th>Prior to University Genetics Content</th>
<th>University Level Genetics Course</th>
<th>University Level Biology Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>%</td>
<td>N</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Yes</td>
<td>33</td>
<td>52.4</td>
</tr>
<tr>
<td>No</td>
<td>29</td>
<td>46.0</td>
</tr>
<tr>
<td>Missing</td>
<td>1</td>
<td>1.6</td>
</tr>
<tr>
<td>Total</td>
<td>63</td>
<td>100</td>
</tr>
</tbody>
</table>

Two respondents (3.2%) reported having a bachelor’s degree in a field other than nursing; 61 respondents (96.8%) denied having a degree in a field other than nursing. In response to the question, “Do you or an immediate family member have an illness with a known genetic component?” 28.6% (n = 18) responded “Yes”, 71.4% (n = 45) responded “No”.

In response to the question, “On a scale of 1 – 5, with 1 indicating “no interest” and 5 indicating “high interest” to what degree are you interested in genetics?” five (7.9%) respondents indicated “no interest”; and 10 (15.9%) indicated “high interest”. The results are displayed in Table 3.
Table 3

*Degree of Interest in Genetics*
(1 indicates no interest; 5 indicates high interest)

<table>
<thead>
<tr>
<th>Response</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>7.9</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>9.5</td>
</tr>
<tr>
<td>3</td>
<td>26</td>
<td>41.3</td>
</tr>
<tr>
<td>4</td>
<td>16</td>
<td>25.4</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>15.9</td>
</tr>
<tr>
<td>Total</td>
<td>63</td>
<td>100</td>
</tr>
</tbody>
</table>

In response to the question, “On a scale of 1 – 5, with 1 indicating “no relevance” and 5 indicating “highly relevant” to what degree do you think genetics knowledge is relevant to your future career as a nurse?” two (3.2%) respondents indicated “no relevance”; and 16 (25.4%) indicated “highly relevant”.

The results are displayed in Table 4.

Table 4

*Relevance of Genetics to Future Career*
(1 indicates not relevant; 5 indicates highly relevant)

<table>
<thead>
<tr>
<th>Response</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3.2</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>4.8</td>
</tr>
<tr>
<td>3</td>
<td>19</td>
<td>30.2</td>
</tr>
<tr>
<td>4</td>
<td>23</td>
<td>36.5</td>
</tr>
<tr>
<td>5</td>
<td>16</td>
<td>25.4</td>
</tr>
<tr>
<td>Total</td>
<td>63</td>
<td>100</td>
</tr>
</tbody>
</table>
Instrument Reliability

Cronbach’s alpha was used as a measure of reliability of the GLAI for this study. The Cronbach’s alpha based on standardized items was .85.

Results for each Research Question

To determine the baseline level of genetic and genomic knowledge in BSN clinical and pre-clinical students, the 44-item survey was exported from Survey Monkey into an SPSS document. The 31 items representing the GLAI were examined and analyzed. Scores were obtained for each respondent. Mean scores for clinical and pre-clinical students were calculated in SPSS. The overall mean score on the GLAI was 17.57 (SD ± 6.06).

Research question 1. What is the baseline level of genetic and genomic knowledge in BSN clinical students? The mean score for clinical students on the GLAI was 18.73 (SD± 5.79) with a possible score of 31.

The lowest scoring item for clinical students on the GLAI was question 24 which addressed the overarching domain of evolution; the concept is genetic variation within and among ethnic groups. Only 26.8% of clinical students answered the question correctly.

The next three lowest scored items for clinical students were questions 15, 26, and 31 which scored similarly, with 39% of clinical students having answered these questions correctly. The overarching domain addressed in question 15 was the nature of genetic material; the concept was that occasional errors in DNA replication result in genetic variation. The domain addressed in
question 26 was evolution; the concept was that genetic variation is the rule rather than the exception in the living world and is the basis for evolution by natural selection. The domain addressed by question 31 was genetics and society; specifically the concept that, genetic technologies are fallible and have unintended consequences; some of which can be harmful to individuals, families, or groups.

The highest scoring item for clinical students was question one, with 90.2% having answered correctly. Question one addressed the domain, nature of genetic material; specifically the concept, genes are segments of DNA which are organized into chromosomes.

After question one, the three highest scored items for the clinical group were two with 82.9% having answered correctly, 12 with 87.8% having answered correctly, and 29 with 82.9% having answered correctly. Question two addressed the overarching domain of genetics and society; specifically the concept that current and future application of genetics technology holds great potential for improving life. The overarching domain addressed in question 12 was the nature of genetic material; the concept was that occasional errors in DNA replication result in genetic variation. The overarching domain addressed by question 29 was genetics and society; specifically the concept that science can often tell us what we can and cannot do, but it does not always tell us what we should or should not do.
Research question 2. What is the baseline level of genetic and genomic knowledge in BSN pre-clinical students? The mean score for pre-clinical students, based on the GLAI was 15.4 (SD± 6.08) with a possible score of 31.

Similar to the clinical students, the lowest scored item for pre-clinical students on the GLAI was question 24, with 4.5% of pre-clinical students having answered correctly. Question 24 addressed the overarching domain of evolution; the concept addressed genetic variation within and among ethnic groups.

The next three lowest scored items for pre-clinical students are items 15, 21, and 25 with 18.2% having answered these questions correctly. The overarching domain addressed in question 15 was the nature of genetic material; the concept was that occasional errors in DNA replication result in genetic variation. The overarching domain addressed by questions 21 and 25 was gene expression. Question 21 tested the concept, the function of a gene and its protein produced can be affected by the environment at one or many of the steps involved in producing a given trait. Question 25 tested the concept, many genes code for proteins which in turn produce individual traits.

The highest scored item for pre-clinical students was question one, with 95.5% having answered correctly. Question one addressed the domain, nature of genetic material; specifically the concept, genes are segments of DNA which are organized into chromosomes. The next three highest scored items for pre-clinical students were questions 12, with 77.3% having answered correctly; 29 with 81.8% having answered correctly; and question 30, with 77.3% having answered
The domain addressed by question 12 was gene regulation; specifically the concept that there are gene variations that result in disease less consistently. The domain addressed by question 29 was genetics and society; specifically the concept that science can often tell us what we can and cannot do, but it does not always tell us what we should or should not do. The domain addressed by question 30 was transmission; specifically the concept that chromosome number is reduced by half during meiosis which results in the formation of genetically different gametes.

Mean scores on the GLAI for clinical and pre-clinical students are displayed in Table 5. Lowest and highest scored items on the GLAI for clinical and pre-clinical students are displayed in Tables 6 and 7.

Table 5

Mean Scores on GLAI

<table>
<thead>
<tr>
<th>Enrolment</th>
<th>N</th>
<th>Mean Score</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical</td>
<td>41</td>
<td>18.7317</td>
<td>5.79</td>
</tr>
<tr>
<td>Pre-clinical</td>
<td>22</td>
<td>15.4091</td>
<td>6.08</td>
</tr>
</tbody>
</table>
Table 6

*Analysis of Selected Lowest Scored Items on the GLAI*

<table>
<thead>
<tr>
<th>Question</th>
<th>Pre-clinical</th>
<th>Clinical</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>4.5</td>
<td>26.8</td>
</tr>
<tr>
<td>15</td>
<td>18.2</td>
<td>39.0</td>
</tr>
<tr>
<td>21</td>
<td>18.2</td>
<td>51.2</td>
</tr>
<tr>
<td>25</td>
<td>18.2</td>
<td>48.8</td>
</tr>
<tr>
<td>24</td>
<td>4.5</td>
<td>26.8</td>
</tr>
<tr>
<td>15</td>
<td>18.2</td>
<td>39.0</td>
</tr>
<tr>
<td>26</td>
<td>45.5</td>
<td>39.0</td>
</tr>
<tr>
<td>31</td>
<td>31.8</td>
<td>39.0</td>
</tr>
</tbody>
</table>

Domain:
- Evolution
- Nature of Genetic Material
- Gene Expression
- Genetics and Society
### Table 7

*Analysis of Selected Highest Scored Items on the GLAI*

<table>
<thead>
<tr>
<th>Question</th>
<th>% Correct Pre-clinical</th>
<th>% Correct Clinical</th>
<th>Domain</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Highest Scored Pre-clinical</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>95.5</td>
<td>90.2</td>
<td>Nature of genetic material</td>
</tr>
<tr>
<td>12</td>
<td>77.3</td>
<td>87.8</td>
<td>Gene Regulation</td>
</tr>
<tr>
<td>29</td>
<td>81.8</td>
<td>80.5</td>
<td>Transmission</td>
</tr>
<tr>
<td>30</td>
<td>77.3</td>
<td>80.5</td>
<td>Transmission</td>
</tr>
<tr>
<td><strong>Highest Scored Clinical</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>95.5</td>
<td>90.2</td>
<td>Nature of genetic material</td>
</tr>
<tr>
<td>2</td>
<td>73.3</td>
<td>82.9</td>
<td>Genetics and Society</td>
</tr>
<tr>
<td>12</td>
<td>77.3</td>
<td>87.8</td>
<td>Gene Regulation</td>
</tr>
<tr>
<td>29</td>
<td>81.8</td>
<td>80.5</td>
<td>Transmission</td>
</tr>
</tbody>
</table>
Research question 3. Is there a difference in the baseline level of genetic and genomic knowledge in BSN clinical and pre-clinical students?

To determine if there is a difference in baseline levels of genetic and genomic knowledge in BSN clinical and pre-clinical students, and if the difference is statistically significant, a 2-tailed independent sample t-test was calculated. The t-test result was 2.13 and the significance was 0.04, which indicates a statistically significant difference at the 0.05 alpha level. Mean scores on the GLAI for clinical and pre-clinical students are presented in Table 5.

Conclusion

In summary, respondents were from all levels of a four-year curriculum with 95.2% having taken at least one university level biology course. With a response rate of 7.4%, the overall mean score on the GLAI was 17.57. A significant difference was noted between mean scores for clinical and pre-clinical students. The mean score on the GLAI for clinical students was 18.73 (SD ± 5.79). The mean score on the GLAI for pre-clinical students was 15.4 (SD ± 6.08). Cronbach’s alpha was used as a measure of reliability of the GLAI for this study. Reliability of the GLAI was determined by a Cronbach’s alpha based on standardized items. The Cronbach’s alpha was .85.
Chapter 5

Discussion

In this chapter the results are discussed. The response rate, sample characteristics, instrument reliability, and results of each research question are discussed in detail. Findings are compared to the literature. The results for selected items on GLAI are provided. Limitations of the study are detailed. Implications for nursing education and recommendations for future research are provided.

Response Rate

The response rate of 7.4% was unexpectedly low, but can be compared to other studies in which data were collected outside of a scheduled class or meeting time. In the study by Edwards and colleagues (Edwards et al., 2006) nurse practitioner faculty attending a conference were surveyed. Forty of the 440 attendees (9%) agreed to participate. In 2012, Calzone and colleagues (Calzone et al., 2012) utilized email technology and a convenience sample of 839 nurses employed by the National Institute of Health with 239 (28%) responding. In comparison to the two research studies mentioned, the population of interest consists of BSN students, who may be less likely than practicing nurses employed by the NIH to participate in an online survey, or advanced practice nurse educators to participate in research.
**Ad hoc power analysis.** Although a priori power analysis indicated that 128 responses would be desirable, the actual number of responses was 63. Using a medium effect size, with alpha set at 0.05, beta set at .20, .60 power was achieved. According to Cohen (1992) although definitions of effect size are subjective, even a small effect size is not trivial, and a medium effect size is noticeable.

Daack-Hirsch et al. (2012) piloted using the GLAI to assess genetic literacy among nursing faculty and undergraduate students. Ninety-six faculty members and 410 students were invited by email to participate. Response rate for faculty members was 30%. Response rate for undergraduate students was 20%. The survey was administered between November 2009 and April 2010. One explanation for the relatively low response rate of 7.4% in comparison to the study mentioned here may be that three weeks did not allow for all willing students to participate.

Sheehan (2001) studied email survey response rates and factors that may influence response rates, and notes that overall response rates to email surveys have decreased between 1986 and 2000. One suggestion is that lower response rates may reflect an overall unfavorable attitude towards the survey industry. Another possibility may be the way students received the invitation to participate. The link to the survey was sent from the office of student services via email. Although assurances of anonymity were given, students may have had some angst regarding the university having access to the students’ knowledge base.
Sample Characteristics

Of the surveys analyzed, 22 (34.9%) were from pre-clinical students; 41 (65%) were clinical students. Of the 510 pre-clinical students 4.3% responded to the survey, and of the 338 clinical students 12.1% responded. One explanation as to why more clinical students responded in comparison to pre-clinical students is that students who are further along in the curriculum may have a greater appreciation the research process.

Thirty-three (52.4%) respondents reported having taken courses that included genetics content prior to attending the university. This could have occurred at the primary or secondary school level, or in a community college, or in some other venue. However, details of where or how participants were exposed to genetics content were not asked in the survey.

Four (6.3%) respondents report having taken a university level genetics course. Sixty (95.2%) respondents reported having taken a university level biology course. Having taken a university level biology course is consistent with the curriculum which requires two biology courses for nursing students prior to enrolling in clinical courses. Two (3.2%) respondents reported having a degree in a field other than nursing is consistent with students entering nursing as a second career choice.

Eighteen (28.6%) respondents reported that either they or an immediate family member has an illness with a known genetic component. The question asked on the demographic data sheet was whether they (the respondent) or an
immediate family member had an illness with a known genetic component, however, there was no question asking what illnesses were experienced. Having had experience with an illness with a known genetic component may have predisposed the student to take the survey. It also may have served to increase their level of genetic and genomic knowledge through awareness.

Responses to the questions regarding degree of interest in genetics and degree of relevance of genetics to their future career in nursing were congruent with each other and encouraging. Eleven students (17.5%) indicated less interest (score 1 or 2 on a scale of 1-5) while 26 (41.3%) indicated more interest (score 4 or 5 on a scale of 1-5). Five students (8%) indicated that they felt genetics was less relevant (score 1 or 2 on a scale of 1-5) to their future nursing career, while 39 (61.9%) indicated they felt genetics was more relevant (score of 4 or 5 on a scale of 1-5) to their future nursing career. These results are also congruent with findings of McCarthy et al. (2008) that knowledge of genetics and nutritional genomics among dietitians was greater in those who considered genetics to be of greater importance to practice. Additionally, having an interest in genetics and viewing genetics as relevant to their future nursing career may have predisposed students to take time to complete the survey.

**Reliability of the Instrument**

Cronbach’s alpha was used as a measure of reliability of the GLAI for this study. The Cronbach’s alpha based on standardized items was .85 indicating a high level of reliability, consistent with the literature. Daack-Hirsch et al., (2012)
used the GLAI with faculty and undergraduate nursing students, calculating Cronbach’s alpha to assess internal reliability. Cronbach’s alpha was 0.69 and 0.58 for faculty and undergraduate nursing students respectively.

**Discussion of Research Questions**

The overall mean score on the GLAI was comparable to Bowling and colleagues’ (Bowling, Huether et al., 2008) study using the GLAI to assess baseline genetics knowledge in undergraduate non-science majors. The overall mean score on the GLAI can also be compared to scores obtained by Daak-Hirsch et al. (2012) who studied undergraduate nursing students and nursing faculty. Comparing overall mean scores on the GLAI, the group comprised of nursing students and faculty (Daak-Hirsch et al., 2012) performed better than the group comprised of only nursing students, who performed better than the non-science majors (Bowling, Huether et al., 2008). That nursing students and faculty performed better than non-science majors is logical in that nursing students and faculty would perhaps have an increased interest or sensitivity to content related to genetics and genomics.

Clinical students scoring significantly higher than pre-clinical students on a test of genetic and genomic knowledge are consistent with Dodson and Lewallen’s (2011) findings with nursing students in a four-year curriculum. Dodson and Lewallen (2011) noted significant differences between freshmen, sophomores, juniors and seniors on the mean number of items on which they had
at least minimal perceived knowledge. Sophomores scored higher than freshmen; juniors scored higher than sophomores; seniors scored higher than juniors.

Clinical students scoring significantly higher than pre-clinical students was not a predicted finding, however it is logical and encouraging, considering that it is in the pre-clinical courses where students are first introduced to genetics and genomics. Then content is added where appropriate in clinical courses.

If students are exposed to basic principles of Mendelian genetics and reproduction prior to enrollment in clinical courses, and then are exposed to more genetic content when it is applicable to courses, and if there is retention of knowledge, then the higher level students should possess a higher level of genetic and genomic knowledge. Experience in the college of nursing, clinical experience with patients, and maturity may increase retention of knowledge overall. Also there is a degree of self-selection in that lower performing students will probably not progress into upper level nursing courses.

**Discussion of Low and High Scored Items on the GLAI**

**Low scored items on the GLAI.** Question 24 was the lowest scored item on the GLAI for both pre-clinical and clinical students. The overarching domain of question 24 is evolution; the concept is genetic variation within and among ethnic groups. Only 4.5% of pre-clinical students and 26.8% of clinical students answered the question correctly. One explanation for so few correct responses on question 24 is that students have not retained knowledge of evolution or an understanding of genetic variation within and among ethnic groups. However, the
question is worded in such a way that respondents are asked to select the incorrect response from five choices. This may have confused students taking the survey. It must be noted that although both groups scored low on that item, the clinical students scored much higher than the pre-clinical students. This is consistent with the above discussion of clinical students’ overall mean scores being higher than those of pre-clinical students.

After question 24, the three next lowest scored items for clinical students were questions 15, 26, and 31, with 39% of clinical students answering those questions correctly. The overarching domain addressed in question 15 is the nature of genetic material; the concept is that occasional errors in DNA replication result in genetic variation. The domain addressed in question 26 is evolution; the concept that genetic variation is the rule rather than the exception in the living world and is the basis for evolution by natural selection. The domain addressed by question 31 is genetics and society; specifically the concept that, genetic technologies are fallible and have unintended consequences; some of which can be harmful to individuals, families, or groups.

After question 24, the three lowest scored items for pre-clinical students are items 15, 21, and 25. Only 18.2% of pre-clinical students answered these questions correctly. The overarching domain reflected in question 15 is the nature of genetic material; the sub-concept is that errors in DNA replication result in genetic variation. Question 21 and question 25 test the overarching domain of gene expression. Question 21 tests the concept, the function of a gene and its
protein produced can be affected by the environment at one or many of the steps involved in producing a given trait. Question 25 tests the concept, many genes code for proteins which in turn produce individual traits.

There was no prediction prior to data analysis regarding which items from the GLAI would score low. Closer analysis of lowest scored items on the GLAI for both clinical students and pre-clinical students reveal potential weaknesses. Questions addressing the domains of evolution, and the nature of genetic material scored low by both the clinical and preclinical groups. Specific concepts that could have been mastered in basic biology courses in the pre-clinical curriculum are: genetic variation is much greater within traditional ethnic groups than among them; and occasional errors in DNA structure and replication result in genetic variation. Other concepts where students scored poorly are: genes code for proteins which produce individual traits; the function of genes and proteins produced can be affected by the environment; without genetic variation there can be no differential selection; and genetic technologies are fallible and have unintended consequences.

**High scored items on the GLAI.** Again, there was no prediction prior to data analysis regarding which items from the GLAI would score high. Both pre-clinical (95.5%) and clinical (90.2%) groups scored highest on question one which addresses the domain, nature of genetic material; specifically the concept, genes are segments of DNA which is organized into chromosomes. This finding is
logical in that both groups were exposed to basic genetics content in their pre-clinical courses.

After question one, the three highest scored items for the clinical group were two (82.9%), 12 (87.8%), and 29 (82.9%). Question 2 addresses the overarching domain of genetics and society; specifically the concept that current and future application of genetics technology holds great potential for improving life. The overarching domain addressed in question 12 is the nature of genetic material; the concept is that occasional errors in DNA replication result in genetic variation. The overarching domain addressed by question 29 is genetics and society; specifically the concept that science can often tell us what we can and cannot do, but it does not always tell us what we should or should not do.

Almost similarly, the next three highest scored items for the pre-clinical group were questions 12 (77.3%), 29 (81.8%), and 30 (77.3%). The domain addressed by question 12 is gene regulation; specifically the concept that there are gene variations that result in disease less consistently. The domain addressed by question 29 is genetics and society; specifically the concept that science can often tell us what we can and cannot do, but it does not always tell us what we should or should not do. The domain addressed by question 30 is transmission; specifically the concept that chromosome number is reduced by half during meiosis which results in the formation of genetically different gametes. Both groups scored well for domains addressing gene regulation, transmission, and genetics and society. Under the domain of the nature of genetic material, students
from both groups scored highest on a question that addressed the concept, genes are segments of DNA; DNA is organized into chromosomes. Students performed equally well on the concept, some genetic variations result in disease less consistently than others. They also scored equally high on the concept that science can often tell us what we can or cannot do, but not what we should and should not do.

**Limitations**

One limitation noted was the use of a convenience sample of students from one College of Nursing which prohibited generalizability of results from one BSN program to another. Another limitation was the low response rate. One factor which may have influenced response rate was use of an online system for recruiting participants and obtaining data from students. The survey was sent to all students enrolled in the BSN program by the student services office. Although students were assured of anonymity, there may have been some skepticism regarding a test of knowledge sent from an official university office. Also, as Sheehan (2001) pointed out, potential subjects may be less willing to participate in research because of high levels of unsolicited email. BSN students may have considered that the amount of time required to complete a survey was prohibitive. Another factor may have been that the survey was open for three weeks and this may not have provided ample time for students to participate. Also, students may have limited appreciation of the importance of participating in nursing research.
Implications for Nursing Education

This study provides a baseline level of genetic and genomic knowledge in BSN students at the University of Louisiana, at Lafayette College of Nursing and Allied Health professions. One implication garnered from these results is that a closer examination of the pre-clinical curriculum would be useful, specifically the biology courses where basic genetic information is taught. If students are leaving their basic biology courses without a clear understanding of evolution, and the nature of genetic material, this should be addressed. Also, students may need a refresher of basic genetic and genomic principles during their first clinical course. This would be to reinforce genetic and genomic knowledge obtained in the pre-clinical biology courses.

The domain of genetics and society is appropriate for clinical students. Application of genetics and genomics should appear as appropriate in the theory portion of clinical courses. Unintended consequences of genetic technology can be discussed within the context of legal and ethical issues in nursing. These are introduced at the freshmen (pre-clinical level) but further addressed in the upper level courses. As genetic and genomic information emerges, it needs to be incorporated into already existing courses. In addition to adding content to coursework already in existence, strategies aimed at raising awareness of genetics and genomics among BSN students should be explored.

The importance of the role of nurse educators in preparing future nurses and nurse practitioners continues to be stressed in the literature (Lea, et al., 2011;
Maradiegue et al., 2013). Nurses need adequate genetic and genomic knowledge if essential genetic competencies are to be appropriately integrated into practice. If nurses are to practice to the full extent of their education, they must be able to assess patients’ genetic vulnerabilities, be willing to advocate for patients and their families, teach, and refer patients while incorporating an understanding of the influence of genetics and genomics. The information required should be acquired during preparation for professional practice.

**Recommendations for Future Research**

The first recommendation is to continue assessment of BSN students’ understanding of basic Mendelian genetics and application of genetic and genomic knowledge in nursing and healthcare. One specific suggestion is to consider repeating the assessment methods used for this project on a periodic basis. A longitudinal investigation may demonstrate trends that will have implications for nursing education. Also there is a need for development of additional valid and reliable instruments for assessment of genetic and genomic knowledge which include specific nursing content.

At the same time, strategies aimed at increasing knowledge of genetics and genomics would be beneficial. An unanswered question is whether there should be a stand-alone course in genetics and/or genomics or to have genetics and/or genomics integrated into all courses in the curriculum. Future research studies to answer this question are recommended.
Another recommendation is to consider a national study of BSN students. A larger study including nursing schools across the nation may provide a better picture of how prepared we are to implement genetics and genomics into practice. Also, a longitudinal study may reveal trends and needs that emerge as genetic and genomic knowledge emerges.

This study could also be replicated with practicing nurses. As genetic and genomic knowledge emerges, nurses already in practice need awareness so they can incorporate that knowledge into patient care. Results of a study with practicing nurses may help staff developers and nurse educators tailor interventions and awareness campaigns for the practicing nurse population.

**Conclusion**

The purpose of the study was to determine BSN students’ baseline level of genetics and genomic knowledge at one university in the US. Everett Rogers’ theory of Diffusion of Innovations and the literature review informed development of the research questions and methods used for this study. A convenience sample with 63 participants representing pre-clinical and clinical students from all semesters in a four-year BSN program answered questions using an online survey format. The response rate was 7.4% and the mean score on the Genetics Literacy Assessment Instrument (GLAI) was 17.57 (SD ± 6.058). The mean score for clinical students, based on the GLAI was 18.73 (SD ± 5.79). The mean score for pre-clinical students, based on the GLAI was 15.4 (SD ± 6.08).
Using an independent sample t-test, the difference between the groups was deemed statistically significant.

Results of this study add to the body of knowledge as it compares level of genetic and genomic knowledge among clinical and pre-clinical BSN students. Specifically, results may inform strategies at raising awareness of genetics and genomics in the BSN population, and future research on BSN students’ knowledge of genetics and genomics. A longitudinal view of student knowledge of genetics and genomics is indicated, as are strategies at increasing awareness of emerging genetics and genomics information.
References


