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Manuscript

Assessing Genomic Literacy in

Advanced Practice Nursing Students Before and After an Intervention

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Doctor of Nursing Practice Manuscript

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Abstract

Introduction

The purpose of this evidence-based Doctor of Nursing Practice (DNP) project was to examine genetics and genomics literacy in advanced practice nursing students before and after an intervention.

Background

As genomics continue to play an emerging role in healthcare, and advancements are introduced into clinical practice, it is critical that nurses be competent in genetics and genomics concepts. There is a fundamental need to incorporate genomics education into nursing school curriculum. However, studies have shown that the majority of faculty across nursing schools in the United States are ill-equipped to teach genetics and genomics concepts. Furthermore, many interventions to increase genetics and genomics literacy among nurses have resulted in minimal improvement.

Methods

Two cohorts totaling 25 advanced practice nursing students were administered the Genomic Nursing Concept Inventory (GNCI), a 31-question multiple choice questionnaire assessing 18 genomic concepts in four categories (Human Genome Basics, Inheritance, Mutations, and Genomic Health Care) before and after a semester-long educational intervention at the University of San Diego. 18 of the students had baccalaureate degrees in nursing (BSN), and 6 had master's degree in nursing (MSN). The BSN cohort received the intervention with face-to-face instruction, while the MSN cohort received it as a virtual/hybrid course. One person in the BSN cohort did not take the pre-assessment but completed the post-assessment. Percentage of correct items and mean scores amongst the two cohorts were calculated and reported.

Results

Students in the BSN cohort had a slight increase in mean percentage score after the educational intervention, although not statistically significant (44% and 49%, respectively).

Students in the MSN cohort had a decrease in mean percentage score in their post-intervention-assessment (38% and 35%, respectively).

Conclusions

Nurses continue to score poorly in genomics literacy, regardless of their level of education. There is limited evidence indicating what the most effective educational interventions are, and at what level of nursing education they should be taught. Additional research is needed to identify the most effective interventions to improve genomic literacy. Genomics curriculum should aim to align with existing genetics and genomics nursing competencies.

Keywords: genomics, genetics, genomic education, genetics nurse, genomic concepts, nursing education

Assessing Genomic Literacy in

Advanced Practice Nursing Students Before and After an Intervention

The completion of the Human Genome Project in 2003 led to an increase in the use of genetic and genomic information by healthcare providers to deliver patient care (Wright et al., 2018). Advancements in genomic technology improved screening and detection of diseases (Wright et al., 2018), and optimized how we combat diseases through personalized and precise approaches (Rehm, 2017). From conception through end-of-life care, genetic and genomic information is used to assess disease predisposition, predict drug responses, develop new drug therapies, and improve quality, safety, and patient outcomes (McDermott et al., 2011; Rehm, 2017).

Although genetic healthcare has existed for decades, prior to recent advancements it had primarily been offered by specialized doctors, nurses, and counselors working in the context of genetic clinics (Godino et al., 2012). These services traditionally included genetic diagnosis and counseling to patients and families affected by rare diseases caused by abnormal chromosomes or single-gene mutations (Godino et al., 2012). In the current healthcare landscape where genomic-driven care is being practiced in settings such as primary care, oncology, and infectious disease (Genomics and medicine, 2020; Whiter et al., 2020), genomics advancements have implications across the healthcare continuum (Calzone et al., 2018b). As the utility of genomics in mainstream medicine continues to grow, so will the need for clinicians with adequate knowledge of genetics and genomics concepts to support patients and families in this new healthcare era.

As the largest group of healthcare professionals worldwide, nurses must be ready to integrate genomic competencies into their everyday clinical practice (Calzone et al., 2018b; Wright et al., 2018). Nurses are essential clinicians who, alongside physicians, play a frontline role in providing genomic-centered care and education to patients and families (Whitley et al., 2020). The purpose of this evidence-based project was to evaluate genomic literacy in advanced practice nursing students at the University of San Diego before and after an educational intervention.

Background

Nurses play a pivotal role in leading change to advance health and implement genomics into everyday patient care, integrating research discoveries into ethical healthcare practice benefiting individuals and societies (Daack-Hirsch et al., 2012; Whitley et al., 2020). Many diseases and conditions that affect the population have a genetic/genomic component that is influenced by environment, lifestyle, and other factors directly impacting patient care and the nursing profession (Clark et al., 2013). While genetics refers to the study of genes and their roles in inheritance, genomics is the study of a person's genes, including interactions of those genes with each other and with the person's environment (National Human Genome Research Institute, 2018).

As genomics continue to shape how healthcare is practiced, nurses must feel confident in their ability to understand and translate genomics concepts into clinical practice. However, research has shown that many nurses lack confidence regarding genomics concepts (Calzone et al., 2012; Calzone et al., 2013). In a national nursing workforce survey of nursing attitudes, knowledge and practice in genomics, Calzone et al. (2013) surveyed 156 registered nurses and found that just 28% ($n = 153/556$) felt they were more or very confident in their ability to decide

what family history information was needed to assess a patient's genetic susceptibility to common diseases such as cancer, heart disease and diabetes (Calzone et al., 2013). In a separate survey of licensed registered nurses employed at the National Institute of Health (NIH) Clinical Center or National Cancer Institute, only 24% ($n = 38/159$) reported being very or somewhat confident in their ability to do the same (Calzone et al., 2013).

Genomic literacy and competency deficits in nurses are widely acknowledged (Calzone et al., 2014; Calzone et al., 2018a; Skirton et al., 2012). In a study assessing genomic literacy of 253 registered nurses and midwives in Australia using the 31-question Genomic Nursing Concepts Inventory (GNCI), the mean percentage score of correct responses was 47% (Wright et al., 2018). In a similar study of 75 practicing nurses in a pediatric hospital in the United States, the mean percentage score was 44% (McCabe et al., 2016). Research into genomic knowledge among nurses has led to many initiatives designed to increase knowledge of genomics concepts in practicing and student nurses, and to facilitate the translation of concepts into clinical practice (Aiello, 2017). Among those initiatives was the development of the *Essential Nursing Competencies and Curricula Guidelines for Genetics and Genomics* in 2006, which was updated with outcome indicators in 2008 (Consensus Panel on Genetic/Genomic Nursing Competencies, 2009; Aiello, 2017). They are evidence-based and define minimal competencies expected of all nurses, regardless of educational level or specialty. The competencies are broken down into two domains: professional practice and professional responsibilities (Aiello, 2017). The outcome indicators define how a registered nurse (RN) can demonstrate genetic and genomic competence (Consensus Panel on Genetic/Genomic Nursing Competencies, 2009; Aiello, 2017). These competencies provided the nursing field with a framework for identifying educational needs of nurses (Aiello, 2017) and were used by the American Association of Colleges of Nursing

([AACN], 2008) to support their recommendation for the inclusion of genetics and genomics into nursing curricula (Aiello, 2017; Jenkins & Calzone, 2012).

Despite initiatives to include genomics education into nursing programs, nurses continue to lack understanding of genomic principles, resulting in healthcare deficits (Whitley et al., 2020). To evaluate genomic literacy among nursing students in Croatia, the GNCI was administered to 53 undergraduate student nurses. The mean percentage score of correct responses was 31.6% (Majstorović et al., 2021). A similar evaluation of undergraduate Canadian nursing students resulted in a mean percentage score of 45% (Dewell et al., 2020).

Academic nursing education and RN preparatory programs must adequately train and prepare nurses to fulfill core competencies that have been put in place. Nurses are a critical part of the healthcare workforce, and nursing courses must incorporate competency guided genomics education into the curriculum (Whitley et al., 2020).

Methods

Instrument

The GNCI is a 31-item concept inventory designed to measure understanding of genetic-genomic concepts most important to nursing practice (Read & Ward, 2015). Its content is drawn from the *Essentials of Genetic and Genomic Nursing Competencies and* consists of four topical categories: genome basics (twelve items), mutations (three items), inheritance (eight items), and genomic health (eight items) (Read & Ward, 2015). Scores range from 0 to 31, with higher scores signifying greater knowledge (McCabe et al., 2016; Ward, 2011).

In a sample of 705 U.S. Bachelor of Science in Nursing (BSN) students, the GNCI was found to have acceptable internal consistency reliability (Cronbach's α 0.77) (McCabe et al., 2016; Ward et al., 2014). Since its development in 2011, the GNCI has been deployed to more

than 3,000 nursing students, over 500 nursing faculty, and many practicing nurses (*Washington State University, n.d.,*)

Design

This study used a purposive sample of advanced practice nursing students enrolled in the Doctor of Nursing Practice (DNP) program at the University of San Diego. There were two cohorts: BSN and Master of Science in Nursing (MSN). The BSN cohort were nursing students enrolled in the BSN to DNP track. The MSN cohort were nursing students enrolled in the MSN to DNP track. The intervention was a full semester course, Pathogenesis of Complex Diseases (DNPC 622), at the University of San Diego, during the fall of 2022. The BSN cohort took the course on-site with face-to-face instruction at the university. The MSN cohort was taught using a hybrid model with students attending the course onsite on the first day of class and the last day of class, and in-between instruction conducted virtually through preassigned modules and assignments. The study was reviewed and approved by the University of San Diego Institutional Review Board (IRB-2023-419).

Intervention

Pathogenesis of Complex Diseases is a doctoral level course at the University of San Diego. The course focused on critical analysis and synthesis of advanced pathophysiology and clinical genetics to examine complex disease states in acutely or chronically ill individuals with an emphasis on multi-system conditions. The objectives of the course included (a) synthesize knowledge of advanced pathogenesis and clinical genetics as a basis for evaluation of patients with multisystem disease states, (b) evaluate subjective and objective clinical findings to formulate differential diagnoses for patients with complex disease states, and (c) explore current therapies and investigational interventions including pharmacogenetics for complex disease

states in the acutely or chronically ill individual utilizing evidence-based practice models (Nolan, 2022).

Sample/Participants

Participants were licensed registered nurses enrolled in a DNP program at the University of San Diego. The BSN cohort participants had bachelor's degrees in nursing, and the MSN cohort participants had master's degrees in nursing. The MSN cohort included some nurse practitioners, although this information was not collected as part of the demographics.

Data Collection

Students were administered the GNCI in an online format prior to the start of their instruction on the first day of their Pathogenesis of Complex Diseases course, to establish baseline genomic literacy. Both cohorts took the survey using the same modality. The GNCI was administered again on the day of their final exam, at the conclusion of course instruction, to assess for changes to baseline scores. Both surveys in each cohort were administered on-site at the university. A link to the GNCI was posted to Blackboard and students willing to participate were asked to click on the survey link. Responses were recorded anonymously. Participants were not compensated, nor was it a requirement to participate.

Data Analysis

Each of the 31 GNCI questions was scored as correct or incorrect, and a total score (range 0–31) was calculated and converted to a percentage score for each participant.

Results

A total of 25 students participated in the study. In the BSN cohort 18 preintervention surveys and 19 postintervention surveys were included in the analysis. One student in the BSN cohort did not take the preintervention survey but took the survey after the intervention. In the

MSN cohort six participants took the pre and postintervention surveys and were included in the analysis.

The BSN cohort (see Table 1) were predominantly female (83.3%, $n=5$) consisted predominantly of non-Hispanic (95%, $n = 18$), Caucasian (42%, $n = 8$), with a mean age of 32 years ($SD = 7.06$). The MSN cohort were predominantly female (84%) with higher mean age 44 ($SD = 6.67$) than the BSN cohort. Half of the participants were Hispanic (50%) and half non-Hispanic (50%). Half reported being Caucasian (50%), one participant reported Asian, Native Hawaiian or other Pacific Islander (17%), and two reported multiracial or some other race (33%).

Table 1

Demographic of Study Population

Characteristic	BSN-Post		MSN-Post	
	Mean	<i>SD</i>	Mean	<i>SD</i>
Age	32.16	7.06	44.16	6.67
Sex	Frequency	Percentage	Frequency	Percentage
Female	18	94.7	5	83.3
Male	1	5.3	1	16.7
Ethnicity				
White or Caucasian	8	42.1	3	50.0
Asian, Native Hawaiian or other Pacific Islander	5	26.3	1	33.3
Multiracial or some other race	4	21.1	2	16.7
Black or African American	2	10.5	-	-
Hispanic				
No (Non-Hispanic)	18	94.7	3	50.0
Yes (Hispanic)	1	5.3	3	50.0
Total	19	100	6	100

In the BSN cohort, the mean percentage correct score was 44% preintervention and 49% postintervention. Mean percentage correct scores for the MSN cohort pre and postintervention were 38% and 35%, respectively (see Table 2).

Table 2

Pre and Post Mean Percentage Scores BSN and MSN Cohorts

Groups	N	Mean Score %	Std Deviation
BSN Prescore	18	44.27	19.08
BSN Postscore	19	48.73	18.02
MSN Prescore	6	37.63	9.72
MSN Postscore	6	35.48	15.24

Figure 1

Mean Percentage Scores BSN Cohort

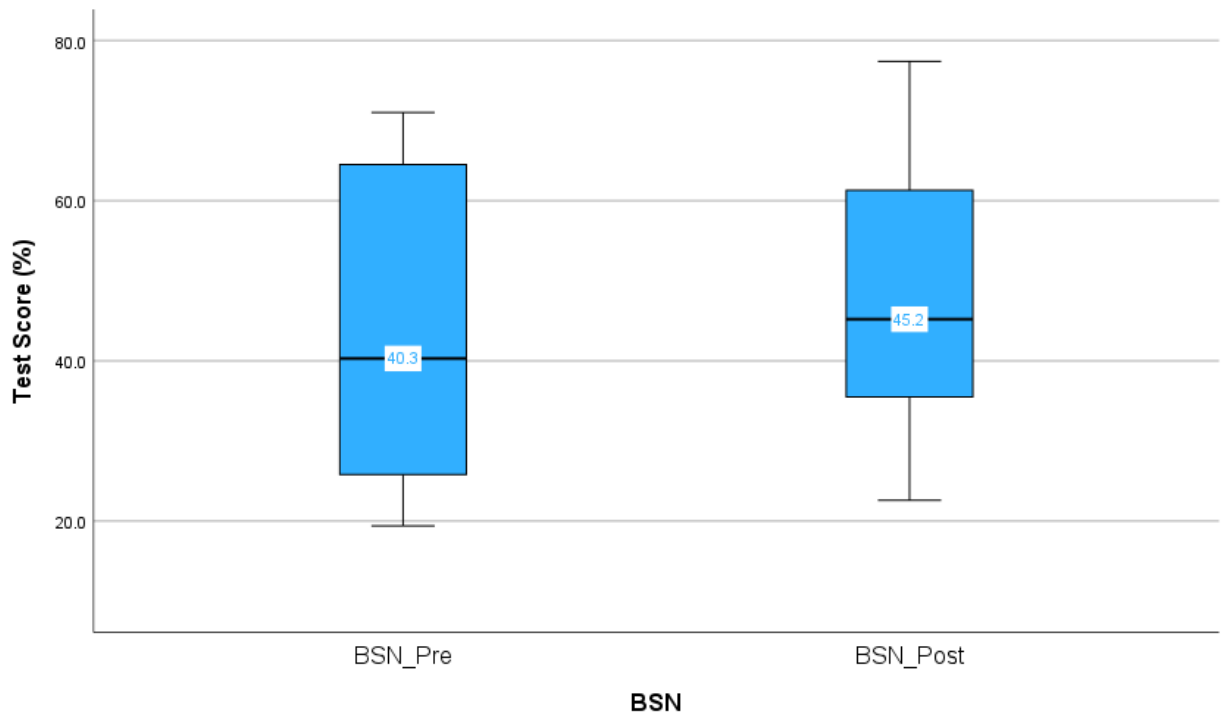
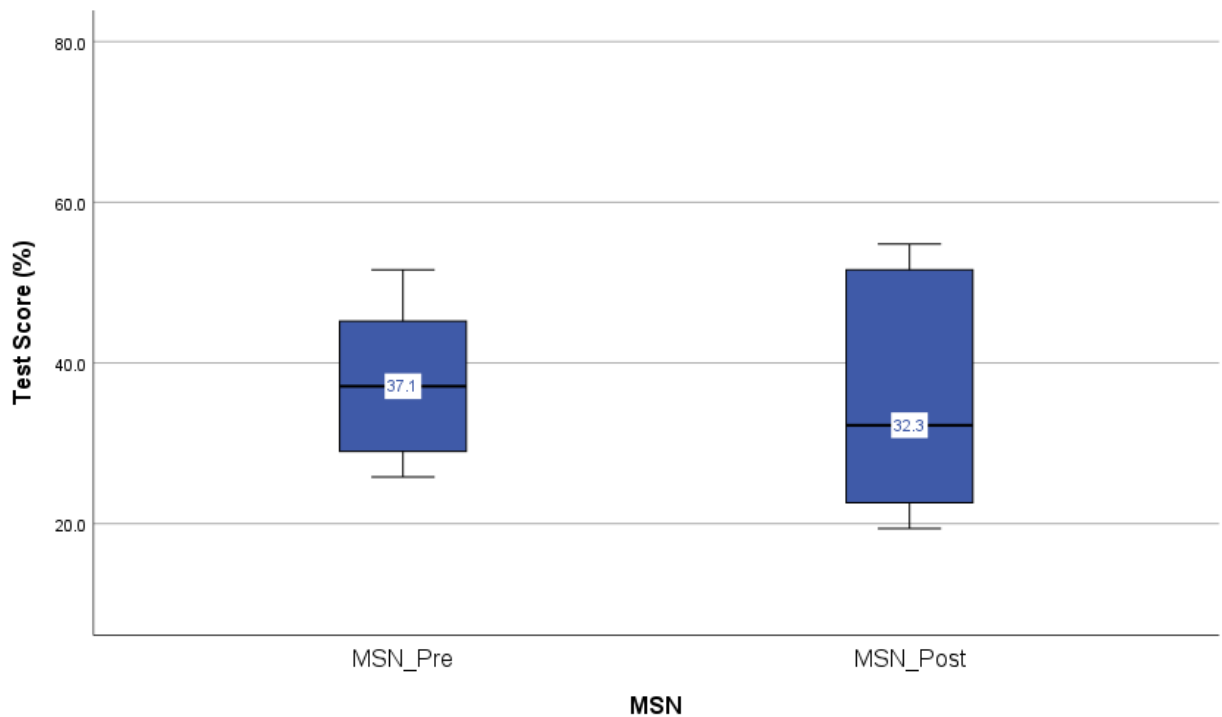


Figure 2

Mean Percentage Scores MSN Cohort



Discussion

This study assessed whether an intervention would change baseline genomic knowledge scores in advanced practice nursing students. Although limitations included a sample size that was too small to make statistical inferences, the findings support the need for further inquiry.

The growing use of genetics and genomics in health care settings requires nurses to have the ability to deliver competent genetic and genomic-focused nursing care. Although it has been suggested that the need exists for development of clear career pathways in genomics for

registered nurses and the wider nursing workforce (Calzone et al., 2018b), genomics education and literacy should not be reserved for nurses seeking to specialize in genomics, but instead must be a requirement for nurses practicing in any healthcare setting (Umberger et al., 2013), to ensure a properly trained workforce. Evidence indicated that patients with genetic concerns will approach practitioners in primary, secondary, and tertiary care settings (Skirton et al., 2010). To ensure a common minimum standard of education and competence, it is important that nurse educators align to use the *Essential Nursing Competencies and Curricula Guidelines for Genetics and Genomics* as a guide in the design and implementation of learning experiences that help nursing students achieve genomic competency (National Coalition for Health Professional Education in Genetics, 2016). Additionally, the *Essential Genetic and Genomic Competencies for Nurses with Graduate Degrees* were created by a consensus panel in 2011. These competencies complement existing nursing competencies and standards of practice and are intended to incorporate genetics and genomics into clinical and nonclinical nursing roles (American Nurses Association, 2016). The competencies apply to anyone functioning at the graduate level in nursing, including but not limited to advanced practice registered nurses (APRNs), clinical nurse leaders, nurse educators, nurse administrators, and nurse scientists (American Nurses Association, 2016).

Recommendations

Although this survey did not include nursing faculty in its assessment, it is widely acknowledged that inadequately prepared nurse faculty has been a barrier to successful incorporation of genomics education into nursing school curriculum (Daack-Hirsch et al., 2011; Dewell et al., 2020; Jenkins & Calzone, 2007; Read & Ward, 2015). Surveys conducted in the United States and Canada to assess nurse literacy in nursing faculty demonstrated that faculty

genomic literacy scores are strikingly similar to those of nursing students (Dewell et al., 2020; Read & Ward, 2015), and that the majority of nursing faculty (70%) report their knowledge of genomics concepts as being poor (Read & Ward, 2015). The ability of faculty to recognize the relevance of genomics in nursing practice and to achieve an adequate level of knowledge with genomics concepts is essential to successful integration of genomic content in nursing education (Read & Ward, 2015).

The findings described in this paper support the need for nursing faculty to conduct inventory of genomic concepts being taught in nursing curricula and to determine if they align with established genomic competencies. Additionally, genomic literacy should be assessed among faculty to establish the need for interventions.

Conclusions

Nurses continue to score poorly in genomics literacy, regardless of their level of education. Many nursing faculty are neither confident in their genomic literacy, nor have they demonstrated greater genomic knowledge than nursing students. Genetic and genomic competencies have been developed and curricular standards have been modified to adequately prepare nursing students. Nurse educators must commit to understanding and acknowledging gaps in curriculum so appropriate interventions can be implemented.

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