

## ORIGINAL RESEARCH

# A snapshot of nurses' understanding, perceptions and comfort level of genomics

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## ABSTRACT

**Objective:** The primary aim of this study explored holistic nurses' self-perceived genomic knowledge, perceptions, attitude and comfort of genomics. A second aim compared results to previous findings of nurse educators and advanced degree practicing registered nurses' genomic knowledge utilizing the same survey instruments.

**Methods:** Design: Recruitment of participants, through the American Holistic Nurses Association (AHNA), was achieved via an anonymous Survey Monkey link of the Genetic and Genomic Literacy Assessment (GGLA) survey. The GGLA survey comprised three aspects: Self-Perceived Genomic Knowledge Survey; Perceptions and Attitudes about Genomics Integration into Nursing Practice Survey and the Comfort Level of Genomics Survey. Method: The GGLA survey link was made available via the AHNA newsletter.

**Results:** Holistic nurses (n = 41) self-perceived genomic knowledge level demonstrated a knowledge base gap in their comprehension and ability to explain genomic concepts to their patients. Majority of holistic nurses were significantly not comfortable with their genomic knowledge (90% or greater). Comparison with nurse educators (n = 53) and advanced degree practicing registered nurses' (n = 36) genomic knowledge provided additional insight.

**Conclusions:** A significant majority of nurses are unprepared to adopt genomics into their practice whilst experiencing a lack of comfort and confidence. The global success of nursing practice resides with its' practitioners being fully informed and competent with all required competencies, especially if nursing is to remain prevalent within personalized healthcare.

**Key Words:** Genomic knowledge, Genomic perceptions, Comfort level, Holistic nurses, Nurse educators, Advanced degree nursing student

## 1. INTRODUCTION

All healthcare providers are required to be knowledgeable of genomic information in order to provide effective and personalized precision care to their patients, especially to those who have a genetically-based condition themselves or within their family. Understanding genomics, the study of the structure and function of the genome and its interactions with the environment, and genetics, the study of inheritance and variation is genetics, is an essential competency of all

healthcare professionals.<sup>[1,2]</sup> Nurses, as part of the integral healthcare community, necessitates remaining informed of this knowledge while integrating it into their patient-centered care and interactions. The continued success of nursing practice resides with its' practitioners being able to be fully informed, competent and comfortable with genetically-based conditions. However, research has shown that practicing nurses demonstrate deficiencies in genomic knowledge and skills.<sup>[3]</sup> This study explored holistic nurses' self-perceived

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genomic knowledge by answering the following questions: 1) What are holistic nurses' self-reported perceptions of their knowledge regarding genomics concepts and conditions; 2) What are holistic nurses' perceptions of the importance of integrating genomics concepts into the nursing practice; 3) What genetic concepts, conditions and topics are integrated into their nursing practice? And 4) Do holistic nurses' have prior education or training in genomics concepts, and are they comfortable integrating this knowledge in their practice? Furthermore, exploration of the results of this small sample of holistic nurses from the United States (US; n = 41) self-perceived genomic knowledge, perceptions and comfort level will be compared to previous findings of nurse educators (n = 53) and advanced degree practicing registered nurses (n = 36) genomic knowledge utilizing the same survey instruments.<sup>[4]</sup>

## 2. BACKGROUND

### 2.1 Genomics

The study of how genetic variants influences health and well-being has led to significant and transformative understanding for all healthcare providers, patients/families and societal communities as a whole.<sup>[5]</sup> Since the completion of the international Human Genome Project and human genome sequencing, the genomic era has redefined personalized precision medicine.<sup>[6]</sup> Foundational core minimum competencies define the knowledge and skills for all healthcare professionals (from pre-licensure preparation to practicing nurse professionals).<sup>[7]</sup> The advancements and emergence of the genomic era has influenced and delineated fundamental healthcare issues, leading to a collective new field of study, known as omics. Omics encompasses “genomics, transcriptomics, proteomics, epigenomics, metabolomics, and microbiomics” and “provides a comprehensive view of the biologic underpinnings of health and disease, which in the era of precision health captures the complexity of molecular biology and provides new tools for nurses to more accurately predict, prevent, diagnose, and treat disease and their related symptoms” (p51).<sup>[8]</sup> All professional healthcare practitioners are expected to be cognizant of omics ramifications that now govern medical and nursing practices.

Studies have already established a knowledge inconsistency in genomic comprehension for the practicing nurse. A very impressive study explored the global landscape of nursing and genetics by the international nursing community, Global Genomics Nursing Alliance.<sup>[9]</sup> Twenty-three global nurse leaders participated in this online survey that explored genomic integration in practice and education, challenges and barriers, and priorities for action in their perspective countries.<sup>[9]</sup> Findings revealed that genomic services were primar-

ily offered in specialized centers, such as newborn and prenatal screening.<sup>[9]</sup> “Genomic literacy and infrastructure deficits were identified in both practice and education settings, with only one country (Israel) reporting a genetic/genomic knowledge and skill requirement to practice as a general nurse”.<sup>[9]</sup> Three countries (Japan, United Kingdom [UK] and US and one region [Europe]) were identified as having existing genomic competencies for nurses with a structured learning framework and five countries have a national society for genetic nurses (Japan, UK, Netherlands, Brazil and Taiwan). Certification in genetic nursing is offered by Japan and the US while Taiwan and UK certify register nurses as genetic counselors.<sup>[9,10]</sup> The Global Genomics Nursing Alliance can provide a collegial network of resources for nursing leaders to improve genetics and genomics education.<sup>[9,10]</sup> The only global genetic nursing organization specifically committed to genomic healthcare, education, research and scholarship is the International Society of Nurses in Genetics.<sup>[11]</sup>

A cross-sectional survey of registered nurses and midwives in Australia explored genomic knowledge utilizing the Genomic Nursing Concept Inventory (GNCI), demonstrating an overall low genomic literacy scores, and 80% of both groups self-reporting their genomic knowledge as poor or average.<sup>[12]</sup> Another study explored genetic education, knowledge and experiences between nurses and physicians in Brazil's primary care, further demonstrating that educational and comfort level gap persists.<sup>[13]</sup> Majority of participants (85.2%) acknowledged receiving some genetic content during their undergraduate education, yet the majority (77.8%) remained unprepared to deliver genomics-based health care.<sup>[13]</sup> A study of registered nurses in the US (n = 191) further demonstrated a limited knowledge of genomic literacy.<sup>[14]</sup> A comparison of self-reported genomic knowledge of nurse educators and graduate degree nursing students in the US demonstrated that both groups had similar genomic knowledge levels and deficits in their ability to integrate this knowledge into practice.<sup>[4]</sup> Overall, “the genomic resources that already exist are not readily accessible or discoverable to the international nursing community and as such are underutilized” (p53).<sup>[10]</sup>

Studies on nursing faculty and students' genomic knowledge continues to establish a genomic literacy disparity. Studies with pre-licensure baccalaureate nursing students utilizing the GNCI revealed continued gaps in genomic concept knowledge and readiness for use in practice.<sup>[15,16]</sup> As students feel more confident with their understanding of genomics and its health implications, these practitioners will become more confident and competent in providing holistic and safe care for their patients.<sup>[15]</sup> Self-rated studies of genetic knowledge in pre-licensure undergraduate or graduate nursing programs further demonstrates an inconsistency in

genomic familiarity.<sup>[1-3,17-20]</sup> Overall, there is a critical lack of genomic understanding, skill and confidence.<sup>[21]</sup> Studies also confirmed that students felt that nurse educators need more confidence in teaching and explaining this content and faculty need to be adequately prepared to actually inform the future professional.<sup>[1,4]</sup>

## 2.2 Holistic nursing

A holistic nurse, who must also be a board-certified registered nurse, incorporates a mind-body-spiritual-cultural-emotional approach that complements traditional nursing care. Holistic nurses often utilize complementary alternative modalities, such as touch and hand-mediated therapies, imagery, relaxation and mindfulness techniques, as well as aromatherapy, homeopathy, herbology and botanical treatments. These modalities can be integrated in all areas of the healthcare setting and in conjunction with traditional Western patient care. It is important to note that nurses in general are professionally trained to treat their patients holistically, meaning to participate in the healing-caring process of the whole person/family. A holistic nurse is an individual who sought additional learning and practice to further enhance their ability to engage with and care for their patients with diverse healing practices. All nurses, including holistic nurses, need to have foundational genomic knowledge to competently provide fundamental information and resources to their patients.<sup>[22]</sup>

## 2.3 Implications for nursing practice

The ever-advancing transformative art and science of nursing instills core ethos of continued personal and professional growth and development, leadership and advocacy for knowledge enhancement for self and others. Informed comprehensive nursing practice necessitates an understanding of the fundamental aspects of the previously stated core competencies, to be fully engaged in the participatory care and education of their patients. Nursing practice, policy, research and genomic knowledge and utilization of knowledge is required for this unique specialty to remain current and continue their advancement in the genomic era.<sup>[22]</sup> Individualized personalized treatments and care based on genetic profiles requires all nurses to have specific genomic knowledge in order to facilitate optimal patient care.<sup>[23]</sup> Genetically-based conditions and disease are the construct across this new horizon of the healthcare continuum. Nurses however have a genomic knowledge deficient leading to a diminished ability to integrate it into their practice.<sup>[21]</sup>

The relevance to practice is substantial. Nurses need to be competent to explain to patients and their families the various implications related to genetically-based conditions, screen-

ing and testing, treatment options, pharmacogenomics and numerous other aspects as previously stated. The “lack of genomic competency among practicing nurses is preventing nurses from adequately screening patients at risk for genetic health compromise and providing appropriate patient advocacy” (p90).<sup>[3]</sup> Being able to integrate genomics into personalized patient-centered care can assist with an overall understanding of health, risk, disease symptomology and progression, therapeutic decision-making, new therapy options and availability and responses/implications to interventions.<sup>[9]</sup> Nurses have a distinct ability to provide a significant and unique perspective to genomic understanding, focusing on health promotion, caring and healing, relationship dynamics between and among family, community and society as a whole.<sup>[2]</sup> Nurses work in a variety of healing domains and patient population diversity, with patients through-out their lifespan, and must be able to implement and integrate genomic understanding at numerous phases and stages during a patients’ well-being process. Facilitating synchronous personalized-centered care, health and wellness integration comprising various dimensions of an interactive relationship constitutes holistic nursing.<sup>[24]</sup> The all-encompassing precision patient care process of nursing now must also integrate and embrace genomics/omics, yet genomic knowledge is not as present as other competencies in the repertoire of nursing care and knowledge.

## 2.4 Conceptual framework

The Diffusion of Innovations (DOI) theory provided the conceptual framework to this study, identifying the knowledge base of holistic nurses related to genomic knowledge, while indicating their comfort/confidence level and attitudes/perceptions as they integrate this knowledge into their practice.<sup>[25,26]</sup> Identifying the holistic nurses’ genomic knowledge base and those who have/have not integrated genomics into their practice may provide insight into the relevance of promoting a wider adoption of genomic knowledge. DOI theory describes different levels of engagement and its hierarchy by which new ideas and competencies/initiatives are implemented into a society or organization.<sup>[25,26]</sup> Identifying the characteristics of nurse adopters, those who have engaged in knowledge enhancement and as such improve their confidence and comfort in integrating genomic knowledge, can provide a foundation in the continued application of genetics in nursing practice.<sup>[27]</sup> Jenkins & Calzone used this theory as the basis for genomic nursing program development, believing that it provided a building block for healthcare providers to translate genetics expertise into practice.<sup>[28]</sup> The hierarchy of knowledge conceptualization is also applicable to the general public/consumer with regards to the multiple dimensions of genetic literacy, revealing a

need for augmenting genomic education and establishing tools for future research.<sup>[29]</sup>

### 3. METHOD

Data collection occurred during 2017-2019 after Institutional Review Board approval was received. Participant inclusion criteria was being a member of the American Holistic Nurses Association (AHNA). Recruitment was achieved with the AHNA assistance with an anonymous Survey Monkey link of the Genetic and Genomic Literacy Assessment (GGLA) survey made available via their newsletter. Email blasts of the GGLA survey link to AHNA members was discussed but never occurred. The GGLA link was available through the researchers' university Survey Monkey account and managed solely by the researcher. The GGLA survey comprised three aspects: Self-Perceived Genomic Knowledge Survey; Perceptions and Attitudes about Genomics Integration into Nursing Practice Survey and the Comfort Level of Genomics Survey. A brief demographic inventory concluded the survey. Completion of the anonymous GGLA denoted consent.

#### 3.1 Study design

##### 3.1.1 GGLA survey: *Self-perceived genomic knowledge*

The GGLA was composed of the Genetic and Genomic Concepts survey<sup>[30]</sup> and modified with additional questions related to perceptions and attitude about genomics integration and comfort level about genomics, totally 27 questions. The Genetic and Genomic Concepts (GGC), a 15-question survey, was initially utilized to evaluate the competency of US baccalaureate nurse educators' genomic knowledge.<sup>[30]</sup> This short 15-questionnaire originated from the AACN Essentials of Baccalaureate Education for Professional Nursing Practice competencies<sup>[31]</sup> and the Essentials of Genetic and Genomic Nursing: Competencies, Curricula Guidelines, and Outcome Indicators,<sup>[32]</sup> with contributions from ISONG members and expert nurse educators. Permission was granted, via email communication, to incorporate the GGC survey.<sup>[30]</sup> Adapting the GGC influenced the researcher to develop the GGLA. The GGLA, as shown in Table 1, includes the GGC genomic knowledge questions with additional questions including: seven questions exploring perception and attitude about genomic integration into nursing practice and five questions exploring the nurses' comfort level about genomics. The validity and reliability of both GGC and GGLA surveys have effectively proven to provide data on self-perceived knowledge genomics concepts.<sup>[1, 4, 30]</sup>

##### 3.1.2 *Perceptions and attitudes about genomics integration into nursing practice survey*

This survey, as Shown in Table 2, comprised seven questions using a 5-point Likert scale of strongly agree/agree,

disagree/strongly disagree to unsure for perceptions and attitudes. Perception and attitude survey explored the importance of genomics for the nurse; importance of preparing nurses to utilize genomics; importance of teaching nurses genomics to keep nursing integral in patient/family care; does family history assessment has little value; work environment motivation; interest in taking a genomics course and importance of nurses to advocate for their patients regarding genomic healthcare issues.

##### 3.1.3 *Comfort level of genomics survey*

Comfort level aspect comprised five questions exploring collecting family history and generating a pedigree depiction; sharing genomic knowledge in work environment; requesting additional education about genetic diseases; comfort in explaining a Mendelian inheritance pattern and comfort in teaching genomic concepts. This survey, as shown in Table 3, also utilized a five-point Likert score of strongly agree/agree comfortable, disagree/not comfortable to unsure.

##### 3.1.4 *Statistical analysis – participant performance*

Descriptive item analysis to the self-perceived genomic knowledge questions were based on correct percentage score to each individual question. Tallies to the perceptions and attitudes about genomic integration and comfort level provided statistical understanding of these aspects. Comparison of holistic nurses' genomic literacy to the researchers' previous study on nurse educators and graduate students provided a unique perspective of practicing nurses' genomic knowledge.<sup>[4]</sup> Given that all of these participants utilized the same GGLA survey, comparison of all findings continued to demonstrate a lack of genomic knowledge and minimal comfort.

##### 3.1.5 *Study limitations*

As this was an In-Kind study with the AHNA for volunteer services rendered, multiple notifications were to be sent by the AHNA to all of their members via their newsletter and blast emails. Unfortunately, these activities did not fully occur and as such, there were only two main periods within the two years of this study (2017-2019) when participants responded. Hence, the significant small response rate. In addition, the sample being solely from United States participants cannot be generalizable to the population of nurses or the nursing profession globally. As this study explored self-perceived genomic knowledge, perceived versus actual genomic knowledge remains variable.<sup>[15]</sup> Finally, the subject matter may have been intimidating to individuals leading to participants unwillingness to participate. Nevertheless, data received does confirm a gap in the genomic knowledge base of these participants and their desire to enhance their educational understanding of this material.

## 4. RESULTS

### 4.1 Participants

Forty-one holistic nurses were female with one male. Ages ranged from 25-70 years of age with the majority being between 41-60 (63.4%/n = 26). The majority had only 0-10 years in holistic nursing (51.2%/n = 21) with the highest degree obtained being a Bachelor of Science in Nursing (BSN; 50%/n = 20). Interestingly, 97.6% (n = 40) did not receive genomic education within their pre-licensure baccalaureate program nor take a genomic course after graduation. This does correlate to genomics, on a global scale, not being fully immersed in pre-licensure baccalaureate nursing curricula.<sup>[9]</sup> The majority indicated interest in exploring strategies to enhance their overall genomic understanding (82.9%/n = 34) and learning how to integrate genomics into their nursing

practice (68.3%/n = 28).

#### 4.1.1 Self-perceived genomic knowledge survey/GGLA item scores for holistic nurses

Of the 15 multiple choice questions pertaining to genomic knowledge, eight questions had over 50% correct responses, with carrier testing having 90.2% (n = 37) and BRCA1 allele understanding at 89.7% (n = 35) having the highest correct percentages. Seven questions had under 50% correct responses with the lowest being understanding what a reciprocal translocation at 10.3% correct (n = 4) and interpreting inheritance pattern on a pedigree having 24.3% (n = 9). As shown in Table 1, the GGLA Item Scores for Holistic Nurse, provides data for this study including data from previous study for comparison.<sup>[4]</sup>

**Table 1.** GGLA Item Scores for Holistic Nurse Including Data from Previous Study<sup>[4]</sup> for Comparison. *Holistic Nurse (HN; n = 41) Nurse Educator (NE; n = 53) RN Graduate Degree Students (RN; n = 36) = Advanced Practice RN students\*/n = 31; DNP students\*/n = 5 (Item scores: n = number of participants; Correct Responses with Percentages)*

Item Question	HN (n = 41)	NE <sup>[4]</sup> (n = 53)	RN <sup>[4]</sup> (n = 36)	APRN* <sup>[4]</sup> (n = 31)	DNP* <sup>[4]</sup> (n = 5)
Item 1: Allele	18 (46.2%)	26 (49%)	19 (52%)	54.84%	40%
Item 2: Phenotypic polymorphisms	20 (52.6%)	27 (51%)	28 (77.8%)	74.19%	100%
Item 3: Reciprocal translocation	4 (10.3%)	8 (16%)	9 (25%)	12.9%	100%
Item 4: Autosomal recessive	15 (36.6%)	23 (45.1%)	16 (44%)	26.6%	40%
Item 5: Somatic cell mutation	19 (48.7%)	28 (54.9%)	23 (63.9%)	70.97%	20%
Item 6: Genetic testing	21 (51.2%)	9 (17.65%)	4 (11%)	12.9%	0%
Item 7: X-linked recessive	24 (61.5%)	25 (51.02%)	18 (50%)	54.84%	20%
Item 8: BRCA1 allele	35 (89.7%)	41 (82%)	33 (91.7%)	93.55%	80%
Item 9: Carrier testing	37 (90.2%)	44 (88%)	33 (91.7%)	93.55%	100%
Item 10: GINA/Health Insurance	32 (82.1%)	43 (87.76%)	33 (91.7%)	93.55%	100%
Item 11: Pregnancy DNA mutations	18 (48.6%)	19 (38%)	14 (38.9%)	34.48%	80%
Item 12: Patient history	33 (80.5%)	43 (86%)	33 (91.7%)	93.55%	80%
Item 13: Pedigree symbol	14 (37.8%)	18 (38.3%)	26 (72%)	80%	40%
Item 14: Penetrance	24 (63.2%)	34 (70.83%)	19 (52.8%)	48.39%	80%
Item 15: Interpreting pedigree	9 (24.3%)	10 (20.83%)	8 (22%)	12.9%	40%
Mean	54.9%	53.09%	56%		
Median	51.2%	51.0%	52.4%		
Standard Deviation	22.64	24.31	26.69		

Note. Data collected from 2014-2015<sup>[4]</sup>

#### 4.1.2 Perceptions and attitudes about genomics integration into nursing practice

As shown in Table 2, six of the seven questions had a majority of over 65% strongly agree/agree while one question was evenly split between strongly agree/agree and strongly disagree/disagree. Taking a genomics course would be beneficial to integrate content had the highest percentage with 87.8% (n = 36) agreeing with advocacy importance having 85.4% (n = 35). Work environment motivating the nurse

to learn more about genomics had an even split between strongly agree/agree and strongly disagree/disagree, with both having 43.9% (n = 18 for each) and 12.2% (n = 5) being unsure.

#### 4.1.3 Comfort level of genomics

Majority of participants were significantly not comfortable with their genomic knowledge (90% or greater), as shown in Table 3. The comfort of collecting a family history/drawing a

pedigree and comfort in teaching genomic concepts both had n = 39 uncomfortable (95.2%) while uncomfortable in sharing genomic knowledge was 92.5% (n = 38) and explaining Mendelian inheritance (90.3%/n = 37) were uncomfortable.

How comfortable the nurse was in requesting additional genomic education had 34.1% (n = 14) being comfortable asking while 61% (n = 25) were unfortunately uncomfortable.

**Table 2.** Perceptions and Attitudes about Genomics Integration into Nursing Practice

Item	Strongly Agree	Agree	Disagree	Strongly Disagree	Unsure	Mean	SD
1. Genomics important for a holistic nurse to know	31.7% (N = 13)	48.8% (N = 20)	12.2% (N = 5)	2.4% (N = 1)	4.9% (N = 3)	2.00	0.99
2. Preparing holistic nurses to use genomics is an important aspect to holistic nursing practice	26.8% (N = 11)	48.8% (N = 20)	19.5% (N = 8)	2.4% (N = 1)	2.4% (N = 1)	2.05	0.88
3. Teaching genomics important to keep holistic nurses as a central partner in patient/family care	31.7% (N = 13)	48.8% (N = 20)	17.1% (N = 7)	2.4% (N = 1)	0	1.90	0.76
4. A family history assessment with genetics/genomics content (i.e.: pedigree, 3 generations, age at diagnosis) have little value for patient care	9.8% (N = 4)	17.1% (N = 7)	29.3% (N = 12)	36.6% (N = 15)	7.3% (N = 3)	3.15	1.09
5. The clinical environment (i.e.: hospital setting; clinical setting; hospital administration) is motivating me to learn more about genomics	19.5% (N = 8)	24.4% (N = 10)	26.8% (N = 11)	17.1% (N = 7)	12.2% (N = 5)	2.78	1.28
6. Taking a genetics/genomics course would help me to fully integrate this content	41.5% (N = 17)	46.3% (N = 19)	7.3% (N = 3)	0	4.9% (N = 2)	1.80	0.94
7. The importance of holistic nurses to advocate for patients and society regarding ethical and legal issues about genomics	41.5% (N = 17)	43.9% (N = 18)	7.3% (N = 3)	0	7.3% (N = 3)	1.88	1.06

**Table 3.** Comfort level of genomics (N = 41)

Items	Strongly Comfortable)	Agree	Disagree	Not Comfortable	Unsure	Mean	SD
1. How comfortable are you in collecting a patient’s family history, drawing a 3-generation pedigree and analyzing that pedigree?	2.4% (N = 1)	0	19.5% (N = 8)	75.6% (N = 31)	2.4% (N = 1)	3.76	0.62
2. How comfortable are you in sharing your knowledge of genomics in the clinical setting?	0	4.9% (N = 2)	26.8% (N = 11)	65.9% (N = 27)	2.4% (N = 1)	3.66	0.61
3. How comfortable are you in requesting more education about genetic diseases and genetic counseling?	22% (N = 9)	39% (N = 16)	26.8% (N = 11)	7.3% (N = 3)	4.9% (N = 2)	2.34	1.05
4. How comfortable are you in explaining the Mendelian inheritance patterns to patients (autosomal dominant; autosomal recessive; X-linked disorders; Mitochondrial)?	2.4% (N = 1)	7.3% (N = 3)	24.4% (N = 10)	65.9% (N = 27)	0	3.54	0.74
5. How comfortable are you in teaching the concepts of genomics to fellow nurses?	2.4% (N = 1)	0	22.0% (N = 9)	73.2% (N = 30)	2.4% (N = 1)	3.73	0.60

**5. DISCUSSION**

Current data findings unfortunately coincide with findings from previous studies (from 2005-2013) that have revealed

the educational disparity in genomic knowledge and the lack of confidence and comfort in disseminating genomic content.<sup>[9,17,19,33-37]</sup> Apparently, there has not been a major

shift in the educational genomic literacy of the nursing profession. A significant majority of nurses are unprepared to adopt genomics into their practice whilst experiencing a lack of comfort and confidence. This study provided insight into the overall genomic knowledge base of holistic nurses compared to nurse educators and advanced degree practicing registered nurses, exemplifying the deficiencies and need for additional education and resources. Comparison of participants in this study to the item scores for nurse educators and advanced degree practicing nursing students surprisingly demonstrated that some of the item questions had a higher percentage correct for the holistic nurse, which comprised 50% BSN levels compared to the nurse educator and graduate students who had advanced degrees or had a genetics course in their pre-licensure undergraduate program.<sup>[4]</sup> For example, holistic nurses scored a higher correct percentage to questions pertaining to genetic testing, X-linked recessive, pregnancy DNA mutations and terminology of penetrance. However, the holistic nurse scored significantly less with their understanding of reciprocal translocation, somatic cell mutation and understanding pedigree symbols. Holistic nurses (24.3%), nurse educators (20.83%) and practicing registered nursing advanced degree students (52.9%) scored poorly on interpreting a pedigree depiction. These self-reported findings of nurses in genomic knowledge demonstrates limited exposure to genetic content and understanding of the material. Limited educational training leading to inadequate competency in applying this knowledge clinically can lead to significant deficiencies in patient care and patient outcomes.<sup>[38]</sup> Safe and effective nursing care must incorporate genomic competencies<sup>[14]</sup> and all nurses need to include this competency into their overall scope and standards of practice. It is apparent that practicing nurses, nurse educators and the students they teach, have a close educational genomic illiteracy.<sup>[1,4,39]</sup> Incorporating genomic education into nursing curricula can enhance nurses' competency and comfort level to incorporate into patient care.<sup>[9,10]</sup> A genetically-based condition can lead to emotional, psychological and social stress on individuals, family members, and communities.<sup>[40]</sup> There must now be an emphasis on preparing nurses to integrate genomics into their patient-centered repertoire of personalized care, thus improving patient outcomes and the overall well-being of society and its members.

The overwhelming majority of the holistic nurses (87.8%), nurse educators (86.8%) and 88.8% of the practicing registered nursing advanced degree students agreed that taking a genomics course would help them to fully integrate this content into their practice. The importance of advocating for patients and society regarding ethical and legal issues about genomics was also strongly agreed upon by all participants,

with 85.4% holistic nurses, 75.8% nurse educators and 100% of the practicing advanced degree students. Interestingly, holistic nurses were split in their attitude that their workplace environment motivated them to learn about genomics with 43.9% agreeing and disagreeing to this item. This attitude was found to be similar to nurse educators (41.5% agreeing; 43.3% disagreeing) and practicing nurses (47.2% agreeing; 50% disagreeing). Personal and organizational characteristics can promote positive opportunities or barriers to such opportunities.<sup>[41]</sup> Finally, the majority of holistic nurses (65.9%) perceived that a family history assessment with genomics content (i.e.: pedigree, 3 generations, age at diagnosis) would have value for patient care as did nurse educators (67.9%) and practicing nurses (58.3%). Family health information is a crucial tool to ensure appropriate genomic healthcare data, thus enhancing and promoting advanced knowledge of disease process, treatment effectiveness and medication safety.<sup>[42]</sup>

The unfamiliarity of genomics and lack of confidence and comfort to discuss, explain, integrate and teach this content continues to be a relevant discrepancy in the nurses' unpreparedness during this genomic era. Nursing education has been slow to integrate genetic and genomic content into pre-licensure and graduate curricula, hence, there still remains a gap in the foundational knowledge base of nursing students, practicing nurses and nursing faculty members.<sup>[43]</sup> The nursing profession and nursing academe need to embrace genomic integration into their practice, curricula and consciousness to successfully participate in the genomic-based care of patients and families. A significant majority of holistic nurses (75.6%) were strongly uncomfortable in collecting a patient's family history, drawing a 3-generation pedigree and analyzing that pedigree. This corresponded to the majority of nurse educators (77.3%) and practicing nurses (58.5%) also being somewhat to strongly uncomfortable with this ability. The majority of holistic nurses (95.1%), nurse educators (79.2%) and practicing nursing students (88%) were uncomfortable sharing their knowledge of genomics in the clinical workplace setting. In addition, 90.3% holistic nurses, 83% nurse educators and 88% practicing registered nursing students were uncomfortable teaching the concepts of genomics to fellow nurses received significantly high uncomfortable responses. Addressing the deficits of genomic knowledge and competency levels can lead to improved patient healthcare outcomes, quality of patient-centered care, a decrease in healthcare costs and enhanced and improved patient safety.<sup>[10]</sup> As confidence and comfort increases, so too will perceptions and attitude of the importance of genomic integration. Nursing, at its core, emphasizes integration of bio-psycho-social-cultural-spiritual entities to ensure effec-

tive and efficient patient outcomes.

## 6. CONCLUSION

Although many recognize genomics as an important component of disease, most practitioners feel unprepared to engage with it in practice. The success of nursing practice resides with its' practitioners being fully informed and competent with all required competencies, especially if nursing is to remain prevalent within personalized healthcare. The ethical, social, and legal obligation requires all nurses to be fully knowledgeable and competent to participate in the genomic era. The first step in this process is with education. Nurses should be self-directed to enhance their genomic knowledge literacy. Clinical implications should inform strategies needed to prepare all nurses to improve

their genomic knowledge. There are numerous educational resources available for self-directed learning.<sup>[22,23,44]</sup> Offering genomic in-services, workshops and webinars providing the basic foundational knowledge could provide guidance in meeting this educational need. It is vital and incumbent for the nursing profession to continue to bestow the foundations of genomics ensuring practitioners adequately prepared to impart genetically-sound guidance and advocacy.

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## CONFLICTS OF INTEREST DISCLOSURE

The author declares that there is no conflict of interest.

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