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National nursing workforce survey of nursing attitudes, knowledge and practice in genomics

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Abstract

Aim—Genomics has the potential to improve personalized healthcare. Nurses are vital to the utilization of genomics in practice. This study assessed nursing attitudes, receptivity, confidence, competency, knowledge and practice in genomics to inform education efforts.

Materials & methods—Cross-sectional study of registered nurses who completed an online Genetic/Genomic Nursing Practice Survey posted on a national nursing organization website.

Results—A total of 619 registered nurses participated. The largest proportion of education level were nurses with a baccalaureate degree (39%). Most (67.5%) considered genomics very important to nursing practice. However, 57% reported their genomic knowledge base to be poor or fair. The mean total knowledge score correct response rate was 75%. Yet 60% incorrectly answered that diabetes and heart disease are caused by a single gene variant. Most (64%) had never heard of the Essential Nursing Competencies and Curricula Guidelines in Genomics. Higher academic education or post licensure genetic education increased family history collection in practice.

Conclusion—Most nurses are inadequately prepared to translate genomic information into personalized healthcare. Targeted genomic education is needed to assure optimal workforce preparation for genomics practice integration.

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Keywords

genetics; genomics; nurses; nursing; nursing practice; survey

Genomics, the study of all genetic variation in combination with environmental, personal and other influences, is transforming all aspects of healthcare [1,2]. Rapidly expanding technology in addition to decreasing costs has facilitated the use of genomics across the entire healthcare continuum in areas such as risk identification, screening, prevention, diagnosis, prognosis, therapy development and therapeutic decision-making including pharmacogenomics. The use of genomic information across the healthcare continuum, also called personalized healthcare or personalized medicine, impacts all healthcare professionals, most especially nurses who represent the largest body of healthcare providers and practice in every setting [3].

The calls for integration of genetics and genomics into the nursing curricula, certification, licensure examinations and continuing education began in the 1960s and have continued since [3–6]. However, it has been almost 20 years since nursing attitudes, knowledge and practice in genetics have been assessed nationally through the American Nurses Association (ANA) [7]. In this benchmark survey of 1000 registered nurses, only 15% reported a course in genetics was available during their nursing education. At that time, 68% reported they were either not too or not at all knowledgeable in genetics. In addition, 48% reported that they relied on their physician colleagues as the primary source of information on genetics and genomics. A small study (n = 77) of a convenience sample of attendees at the 2006 National Black Nurses Association found that 56% indicated their knowledge was poor or fair but they were interested in genetics awareness training and 78% indicated they would like to learn how to complete a family health history [8]. A study of 5915 lay respondents reporting a genetic condition in their family found that only 35% felt their healthcare provider was knowledgeable and competent in genomics and 4% felt their provider made appropriate healthcare referrals [9].

In 2005, the Essential Nursing Competencies and Curricula Guidelines for Genetics and Genomics were established [10]. Since that time, the competencies have been expanded to include outcome indicators consisting of specific areas of knowledge and clinical performance indicators, and the competencies were leveled for advanced nursing practice [11,12,101]. With these competencies well established, now is the optimal time to reassess attitudes, practices, receptivity, confidence and competency of integrating genomics into nursing practice. A current baseline will provide the benchmark from which to design and subsequently measure effectiveness of a national genomic nursing educational initiative.

Theoretical framework

Rogers Diffusion of Innovations (DOI) was utilized as the theoretical framework to guide this project [13]. Rogers defines an innovation as a practice that could be perceived as new. While genomics is not new, the fact that the majority of practicing healthcare providers have limited to no education in genetics and genomics, coupled with the broad clinical application of genomics, meets Rogers' definition of an innovation. The dimensions of the theory include: the innovation (i.e., genomics); communication channels used for dissemination; time; and the social system consisting of the healthcare community in which genomics is being introduced. The DOI theory considers antecedents that play a role in innovation diffusion to be adopter characteristics, in this case, nurses and their knowledge about genomics. Attitudes regarding the innovation held by the adopter also influence innovation adoption decisions.

Materials & methods

Aim

The purpose of this study was to assess attitudes, receptivity, confidence, practices and competency of registered nurses in genetics and genomics. This is a hypothesis-generating study and the information obtained will be used to inform genetic/genomic nursing education initiatives targeting deficits identified from the survey.

Instrument

The survey instrument used in this study measured the domains of the DOI theory [13]. Details about the instrument development originally in family practice physicians, then modified for nursing and pilot testing in a nursing population have been reported elsewhere [14,102]. See Table 1 for the conceptual and operational definitions utilized in the instrument [14]. The instrument consists of nine sections assessing Roger's domains including attitudes, receptivity, confidence, competency, knowledge, decision, adoption, as well as the use of race/ethnicity and demographics. Survey items consist of multiple choice, dichotomous yes/no, and Likert scale questions focused on the genomics of common disease and family history, both of which make up core knowledge and are practice-expected skills of all nurses regardless of academic preparation, clinical role or specialty, and are not dependent on cost or access to technology [11]. Validation of the instrument at the time of development was performed with family practice physicians. This included structural equation modeling which assessed the degree to which instrument items aligned with the domains of the DOI. Structural equation modeling revealed the comparative fit index = 0.93; >0.9, the Tucker–Lewis index = 0.92; >0.9, the root mean square error of approximation = 0.039; 90% CI: 0.036–0.042, <0.08 and the standardized root mean square residual = 0.056; <0.1, all indicating the instrument items fit the DOI model. Standardized path weights were $p < 0.001$, which were all statistically significant [102]. The instrument is open access and available as supplemental online material [14]. Family history utilization was used as evidence for practice integration because this falls within the scope of practice of all registered nurses, and is not cost-dependent. Family history assesses the expression of the entire genome within family members as well as taking into account the environment in which family members live, cultural factors that influence health behaviors as well as personal risk factors that may influence expression of genes. The Genetic Variation Knowledge Assessment Index (GKAI) was used to assess nurses' scientific knowledge of genetic variation, and the Racial Attributes in Clinical Evaluation scale to investigate health professionals' use of race in clinical practice [Bonham VL *et al.* Physicians' knowledge, use and beliefs about race and genetic variation: new measures and new insights (2013), Submitted]. Confirmatory factor analysis found that GKAI number of correct answers ranging from 0–6 resulted in a mean = 3.28, standard deviation = 1.17 and was roughly symmetric and unimodal [Bonham VL *et al.* Physicians' knowledge, use and beliefs about race and genetic variation: new measures and new insights (2013), Submitted]. Only two questions from the GKAI are included in the analysis reported in this manuscript. The Racial Attributes in Clinical Evaluation scale has an $\alpha = 0.86$ for seven items [Bonham VL *et al.* Physicians' knowledge, use and beliefs about race and genetic variation: new measures and new insights (2013), Submitted] and its data are being reported elsewhere.

Design

This study utilized a convenience sample of self-selected registered nurses who volunteered to complete the survey from October 2009 to January 2010, which was posted online on the ANA website [103]. The study was reviewed and approved by the West Virginia University Institutional Review Board and the NIH Office of Human Subjects Research. This study was

considered to be Code of Federal Regulations (45 CFR 46) exempt because respondents were anonymous and there were no risks to participants.

Sample/participants

Recruitment for this study occurred through the ANA. Strategies included a posting on the Nursingworld website, a cover story in The American Nurse, as well as email announcements to subscribers of the ANA daily SmartBrief and the weekly e-newsletter, the Nursing Insider. The survey was open for completion for a total of 4 months. Eligible participants were licensed-registered nurses who accessed the survey using one of the above mechanisms. No incentive for survey completion was provided. Survey instructions included the phone number and email addresses of the study investigators to contact with any questions or concerns, as well as contact information for the West Virginia University institutional review board.

Data collection

Data were prospectively collected using online survey methodology taking about 20 min to complete. No personal identifiers were collected, which included programming the survey to have no ability to collect internet provider addresses. Anonymous individual survey data was assigned a random subject number and stored in files that were password protected and accessible only to study personnel.

Data analysis

The answers to all survey questions were summarized using descriptive statistical techniques. χ^2 -tests were used to assess the relationships between survey items with categorical responses. A total knowledge score was calculated by transforming 12 representative knowledge questions into categorical variables with two possible responses, correct or incorrect, followed by summing the total number of correct answers out of 12. The 12 questions included in the knowledge score assessed knowledge of the components of family history, the role of the nurse in genomics, the value of family history in healthcare decision-making, the genomics of common diseases and basic genetic concepts. This score was calculated only for those who answered all 12 knowledge questions (442 nurses). A χ^2 -test was used to assess the relationship between correct versus incorrect responses to the knowledge questions and the field of highest earned degree (nursing vs any other field). The level of significance was $\alpha = 0.05$, and all tests of statistical significance were two-tailed. One-way analysis of variance (ANOVA) followed by Tukey's *post-hoc* test to compensate for different levels of education were then used to see if there were differences in the mean knowledge scores between different levels of education. Data were analyzed using IBM® SPSS® Statistics (Sommers, NY, USA) for Windows, Version 19.0.

To determine an adequate sample size, a power analysis was performed using the G*Power 3 software (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany) for the most complex statistical test, which is one-way ANOVA. To detect a medium effect with 80% power at the 0.05 significance level for a one-way ANOVA with four groups, the minimum required sample size is 180 participants. To control for multiple testing, a significance level of 0.001 was considered for the power analysis, and the required sample size in that case is 356 [15]. The sample size for this study was adequate.

Results

Study sample

Survey data were obtained from 620 nurses. One participant's highest nursing degree was as a licensed practical nurse and therefore was not eligible, resulting in a total of 619 registered nurses for analysis. Table 2 summarizes the characteristics of the eligible nurses.

Participants' ages ranged from 21 to 76 years with a mean of 51 years, the majority were female (96%) and white (89%). The majority (41%) reported their highest level of nursing education as a baccalaureate degree, 31% had a master's degree, 17% had an associated degree, 8% held a PhD and 3% were diploma prepared. A total of 168 nurses (27%) held non-nursing degrees in addition to their nursing education. The majority (39%) reported their highest level of education (nursing as well as non-nursing) was a baccalaureate degree, 34% had a master's degree, 14% had an associated degree, 11% held a PhD and 2% were diploma prepared. A total of 54% indicated their primary role was patient care, 20% were in education and 9% were in administration.

Attitudes/receptivity

The majority of respondents felt it was very important (67.5%; $n = 410/607$) or somewhat important (26.7%; $n = 162/607$) for nurses to become more educated about the genomics of common disease. The most frequently identified advantages of integrating genomics into practice included better decisions about recommendations for preventive services (84.8%; $n = 525/619$), genetic risk triaging (82.6%; $n = 511/619$), better treatment decisions (79.2%; $n = 490/619$) and improved services to patients (69.0%; $n = 427/619$). Potential disadvantages of integrating genomics into practice included the potential to increase insurance discrimination (62%; $n = 386/619$) and an increase in patient anxiety regarding risk (47%; $n = 290/619$).

Nurses who indicated it was important to become more educated about the genetics of common diseases were also more likely to correctly report that a family history that includes second- and third-degree relatives should be taken on every new patient ($p < 0.001$). Nurses who indicated it was important to become more educated about the genetics of common diseases were also more likely to agree that an advantage of genetics was better treatment decisions ($p < 0.001$) and that family history taking should be a key component of nursing care ($p < 0.001$). However, nurses who felt that integration of genomics would result in a greater burden of nursing responsibility were more likely to report that they rarely (36.0%) or never (37.3%) collected family histories ($p = 0.004$). Nurses who felt that genetic integration into practice would increase insurance discrimination rarely (8.1%) or never (87.1%) contacted a genetics healthcare professional for consultation ($p < 0.001$). Higher levels of academic education appeared to influence views about genetics as nurses with higher levels of academic education were more likely to agree that there is a role for nurses in counseling patients about genetic risks ($p = 0.004$).

Most nurses (71.3%; $n = 360/505$) reported that they intended to learn more about genetics/genomics. Furthermore, 73% ($n = 368/506$) indicated that they would pursue such education on their own time. Overall, most (81.2%; $n = 409/504$) would encourage the ANA to support a genetics and genomics awareness initiative. Similarly, of the 47% ($n = 291/485$) who were members of ANA, 81% ($n = 235/291$) would personally support and 85% ($n = 248/291$) would encourage ANA to support a genetics and genomics awareness initiative.

Confidence of nurses

Just 27.5% ($n = 153/556$) felt they were more confident or very confident in their ability to decide what family history information is needed to assess a patient's genetic susceptibility

to common diseases such as cancer, heart disease and diabetes. The majority reported that they were not at all or only a little confident in providing patients with information about the availability (59%; $n = 324/551$), risks (61%; $338/553$), benefits (51%; $n = 279/553$) and limitations (60%; $n = 328/550$) of genetic testing for common diseases. Additionally, more than half of the survey respondents (55%; $n = 304/549$) felt not at all or a little confident in facilitating referrals for genetic services. Nurses who agreed or strongly agreed that family history should be a component of nursing care were also more confident in deciding what family history is needed to tell something about a patient's genetic susceptibility to common diseases ($p < 0.001$); using family history information to support treatment decisions for patients who have common diseases ($p < 0.001$) and counseling patients about inherited risk for common diseases ($p < 0.001$).

Competency/knowledge

Self-reported genetic knowledge assessments are provided in Table 3. The majority felt their understanding of the genetics of common diseases was poor or fair (57%; $n = 288/510$) as was their overall genetic/genomic knowledge (63%; $n = 318/509$). Only 36% ($n = 184/508$) indicated that they had taken a course that included genetics as a major component since they obtained their nursing license. A total of 64% ($n = 342/508$) of participants had never heard of the Essential Nursing Competencies and Curricula Guidelines in Genomics. With regard to family history-specific knowledge elements, as the level of nursing education (diploma through to doctorate) increased, the nurses tended to accurately report that a family history should include second- and third-degree relatives ($p = 0.048$). When a patient indicated a disorder in the family, nurses always collected the age of diagnosis (41%; $n = 200/483$), the relationship to the patient (83%; $n = 403/483$), race or ethnic background (49%; $n = 233/477$), age at death from the condition (49%; $n = 234/479$), as well as maternal and paternal lineages (66%; $n = 320/484$). Responses varied by disease as to the degree to which nurses felt genetics had clinical relevance to a wide range of common health conditions. For example, only 55% ($n = 267/486$) reported that hemochromatosis, an inherited condition, has genetic predisposition.

To generate a measure of knowledge and competency, 12 knowledge questions (Table 4) were selected to calculate a total knowledge score. This score was calculated only on 442/619 participants who responded to all 12 questions. No differences were found in correct versus incorrect response frequency to individual knowledge score questions based on whether the entire sample (619) or only the 442 knowledge score participants were assessed. The mean total knowledge score correct response was 8.99/12 (74.9%) questions, with a median of 9.00/12 (75%) and a standard deviation of 1.69. The minimum score was 1/12 (8.3%) and the maximum score was 12/12 (100%) correct answers. The majority correctly responded to questions about whether genomic risk (as indicated by family history) has clinical relevance for diabetes (99.1%; $n = 438/442$) and coronary heart disease (98.9%; $n = 437/442$). Items from the Bonham and Sellers Human Genetic Variation Knowledge Index were used to further evaluate the specifics regarding what nurses understand about genomics of these common diseases. The majority (60.6%; $n = 268/442$) incorrectly stated that diabetes and heart disease are caused by a single gene variant. Overall, there was a statistically significant relationship between higher levels of education and correct response to this question ($p < 0.001$). Doctorally prepared nurses responded correctly (67.3%) with the percentage correct continuing to decline with level of education (54.7% master's degree, 28.5% baccalaureate degree, 22.7% diploma/AD). There was a statistically significant difference between those whose highest level of education was in nursing (38.3%) versus a non-nursing field (54.8%). Nurses whose highest degree was in a non-nursing field were more likely to correctly answer the question about diabetes and heart disease being caused by a single gene variant ($p = 0.014$).

Decision/adoption

Of those who reported actively seeing patients, utilization of genomics in practice was measured by assessment of family history utilization. A total of 6% ($n = 22/359$) always, and 12% ($n = 45/359$) often, reported taking a family history, while 21% ($n = 76/359$) responded that they occasionally and 60% ($n = 216/359$) had rarely or never assessed a family history in the prior 3 months. A total of 7% ($n = 25/357$) reported that they always updated a family history for continuing patients in the prior 3 months, while 55% ($n = 195/357$) rarely or never updated a family history within the same time period. Nurses who reported an advantage to integrating genetics into practice led to better treatment decisions were more likely to have reported that they always or often collect a family history ($p = 0.014$). Additionally, nurses reporting more confidence in their family history collection skills were more likely to have often or always collected family history ($p < 0.001$). The higher the level of nursing education, the more likely a nurse was to have often or always collected family history ($p = 0.022$). Additionally, nurses who had attended a course since licensure that included genetics were also more likely to have often or always collected family history ($p < 0.001$).

While the majority of nurses indicated that they intended to learn more about genetics, only 29% ($n = 144/503$) knew whether there were any courses on genetics available to them. Most said they would not be able (44%; $n = 216/504$) or did not know (22%; $n = 110/504$) whether they would be able to attend a course during work hours. Interestingly, 73% ($n = 368/506$) indicated they would be willing to attend a course in their own time.

Discussion

The survey findings provide clues to genomic nursing knowledge deficits that are important to correct in order to enhance genomic clinical translation and realize the benefits of personalized healthcare. For instance, the majority of nurses identified an increase in insurance discrimination as a potential disadvantage to integrating genomics into practice. This raises the concern that nursing knowledge about the Genetic Information Non-Discrimination Act [104] may be lacking, as well as knowledge of the limitations of Genetic Information Non-Discrimination Act. Additionally, while the mean total knowledge score (8.99/12) was higher than the investigators hypothesized, drilling down into specifics reveals significant knowledge gaps. Specifically, the majority of nurses thought diabetes and heart disease are caused by a single gene variant. These findings provide insight into educational deficits that can be readily addressed. Furthermore, these data also provide some preliminary evidence on how important it is to correct these knowledge deficits. Consider the finding that those nurses who felt that genetic integration would increase insurance discrimination; in practice those same nurses rarely or never contacted a genetics healthcare professional for consultation.

Almost 20 years have elapsed since an assessment of nursing attitudes, receptivity, confidence, practices and competency of nurses in genetics has been conducted. In that interval, an astounding number of discoveries in understanding the implications of genomics have occurred, many of which have clinical relevance. There have been a number of studies outside the USA that have assessed nurses' attitudes with respect to genetics and genomics. However, given the variations in scopes of practice related to genomics internationally or that the populations studied were either nursing faculty or students, these studies are not optimal for comparison. We did, however, compare the findings from the original ANA study by Scanlon *et al.* to this current assessment which revealed one especially disturbing trend [7]. Scanlon *et al.* found that obtaining a family history including genetic information fell into what they defined as a second cluster of activities of which 20–30% of nurses never performed [7]. Yet, despite a series of national initiatives including the Surgeon General's

Family Health History Initiative [105] launched in 2004, this study found that 60% of nurses reported never or rarely collecting a family history. Further research is needed to elucidate the reasons for this significant decline in the collection of family history information. Critical to this assessment will be the role electronic health records (EHRs) may have in the decline in family history assessment, given that many EHRs do not have adequate mechanisms for family history documentation [16].

The theoretical framework DOI denotes that the dissemination, implementation, adoption and adoption sustainment of an innovation hinges upon a number of factors [13]. These include characteristics of the adopter, attitudes regarding the innovation, perceived advantage of the innovation, knowledge and contextual factors that may facilitate or impede adoption [13]. This study found that the majority of registered nurses felt genomics was important to nursing practice, a critical step in the adoption pathway. However, many had knowledge deficits, were not confident in their practice and were unaware of the Essential Nursing Competencies and Curricula Guidelines in Genetics and Genomics. There was limited evidence of adoption as measured by the utilization of family history although higher academic education or postlicensure genetic education increased family history collection in practice indicating that additional education initiatives may positively influence adoption if the impact of any contextual factors, such as the EHR, are adequately addressed. Remarkably more than 70% indicated a willingness to pursue genomic education on their own time, giving some indication that nurses recognize the advantages of genomics and are receptive to adoption given adequate preparation and support.

Limitations

This study has limitations that influence the interpretation of the findings. First, we are not able to calculate a total response rate given the method of recruitment. We did not perform an analysis to determine if there were differences in characteristics of participants who responded or did not respond to specific questions. This survey does not assess all DOI domains that may affect innovation adoption such as personal factors or the environment in which an individual works. We also did not assess whether any of the responding nurses were retired with the exception that nurses had to respond to questions related to the current primary area of practice. To partially address these deficits, we have compared the demographics of this sample to that of the general nursing population. This sample consisted of a substantially higher proportion of nurses educated at the baccalaureate level or higher when compared with the general nursing population (84.3 vs 50.0%). The mean age of this population is slightly higher (51 vs 46 years) and consisted of more white, non-Hispanic nurses (89 vs 83%) when compared with the general nursing population [106]. Therefore, this study may not be a true representation of the general nursing population with regard to education level and ethnic diversity of the profession. To address the ethnic diversity deficit, a study using a modified version of this survey instrument is already underway in collaboration with the National Coalition of Ethnic Minority Nurse Associations which includes a larger population from the National Black Nurses Association than that reported in the Spruill *et al.* study [8]. In addition to these comparisons, the recruitment method used for this study is subject to recruitment bias because of registered nurses' self-selection to participate. This further limits the generalizability of the findings.

Conclusion

Several genomic knowledge deficits in the nursing workforce were revealed in this study. Rogers' DOI specifies that knowledge is a critical element for successful diffusion and sustained adoption of an innovation, in this case genomics [13]. Most respondents felt genomics was important but felt inadequately prepared to incorporate genomics into their

practice. However, the majority of nurses were receptive to learning more, the fundamental first step to being an integral interdisciplinary member of the healthcare team translating genomic discoveries to improve health outcomes. Findings from this study clearly highlight areas of competency deficits amenable to education and justify the need for a national genomic nursing educational initiative. This study provides the essential benchmark from which to measure outcomes of a national genomic nursing education initiative. Targeted genomic education is needed to assure optimal workforce preparation for use of genomics in personalized healthcare.

Future perspective

Genomic information that has clinical and analytic validity, as well as clinical utility, will continue to emerge. Advances in technology have brought healthcare to the precipice of the US\$1000 genome, a cost approaching those of other existing medical tests. This brings personalized healthcare within reach, offering the potential to improve health outcomes while reducing costs. The immediate challenge for the entire interdisciplinary healthcare workforce, including but not limited to nursing, is to prepare the workforce to be competent in genomics to responsibly translate these findings into practice in order to realize those benefits.

Registered nurses are the largest group of licensed healthcare professionals who directly affect public welfare and patient safety, practice in all settings and continue to be the public's most trusted healthcare provider. We anticipate that the growth of genomic information with clinical utility is only going to expand the role of the nurse in educating and utilizing genomic information. Additionally, the Affordable Care Act will serve to continue to increase public access to healthcare services further necessitating the use of genomic technology and information to identify and improve health while controlling costs.

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Executive summary

Genomics is transforming healthcare

- Genomics is impacting the entire healthcare continuum.
- Genomics is being used in risk identification, screening, prevention, diagnosis, prognosis, therapy development and therapeutic decision-making, including pharmacogenomics.
- As the cost of genomic technologies continues to decline, utilization of genomics becomes clinically relevant.

Nursing competency

- Competencies that define the minimal competency in genomics expected of all nurses regardless of level of academic education, specialty practice area or role have been developed by consensus and endorsed by 50 nursing organizations.
- The competencies have been leveled for nurses with graduate degrees.

Change theory & diffusion of genomics as an innovation

- Several factors influence the rapidity of integrating an innovation into practice including knowledge, the social system and characteristics of the innovation.
- Genomics complexity in an environment of limited to no healthcare provider knowledge of genomics is inhibiting translation into practice.

Limited evidence of nursing competency & translation into practice

- Nurses believe genomics is important to healthcare.
- Nurses have insufficient knowledge and confidence to integrate genomics into practice.

Conclusion

- Nurses are receptive to learning about genomics.
- A national nursing education initiative in genomics is needed.
- A competent nursing workforce is critical to the effective utilization of genomics in personalized healthcare.

Table 1

Conceptual and operational domain definitions and related survey items.

Domain	Conceptual definition	Operational definition	Survey instrument items
Attitudes/receptivity	The relative advantage offered by the innovation Perceived attributes of the innovation including the recognized need for the innovation, as well as contextual factors such as identification of communication channels that facilitate or hamper adoption and sustained implementation	Perceived importance, advantages and disadvantages of integrating genomics into practice The complexity of integrating family history into practice. Perception of the value of family history in patient care and their personal practice	Part one: questions 1, 2 and 3 Part two: questions 2 and 3c Part three: question 6
Confidence	Level of certainty that knowledge about the innovation is accurate	Confidence in: discussing genetics with patients; deciding what family history information is relevant to assessing genetic susceptibility; availability, risks, benefits and limitations of genetic testing; facilitating referral for genetic services	Part two: question 1
Competency/knowledge	Recognition of the innovation and evidence of understanding the innovation and its function	Knowledge of the genomics of common disease, and the family history information needed to evaluate patients' genetic susceptibility	Part two: question 3 Part four: questions 1, 2 and 4 Part five: questions 1 and 2
Social system	The environment in which the innovation is being introduced, the interconnected entities involved in shared problem solving	Supervisory support for nurses using genomics, and institutional financial support for genomic continuing education	Part six: question 1
Decision/adoption	Observation of use of the innovation	Utilization of family history within the past 3 months	Part three: questions 1, 2, 3, 4 and 5

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Table 2

Demographics of study sample.

Demographics	n (%)
<i>Sex (n = 481)</i>	
Male	20 (4.2)
Female	461 (95.8)
<i>Age (n = 472)</i>	
Mean, years (range)	50.7 (21–76)
<i>Race (n = 476)</i>	
White	424 (89.1)
Asian	8 (1.7)
Black/African–American	14 (2.9)
American Indian/Alaska Native	4 (0.8)
Native Hawaiian/Pacific Island	2 (0.4)
Other	24 (5.0)
<i>Highest level of nursing education (n = 483)</i>	
Diploma	16 (3.3)
Associate degree	83 (17.2)
Baccalaureate degree	196 (40.6)
Master's degree	148 (30.6)
Doctorate degree	39 (8.1)
<i>Highest level of education (nursing and non-nursing combined) (n = 483)</i>	
Diploma	9 (1.9)
Associate degree	67 (13.9)
Baccalaureate degree	189 (39.1)
Master's degree	164 (34.0)
Doctorate degree	54 (11.2)
<i>Primary role (n = 427)</i>	
Administration	38 (8.9)
Education	85 (19.9)
Research	16 (3.7)
Patient care	231 (54.1)
Student	9 (2.1)
Other	48 (11.2)

Table 3

Knowledge measures of study sample.

Measure	n (%)
<i>Understanding of the genetics of common diseases (n = 510)</i>	
Excellent	7 (1.4)
Very good	66 (12.9)
Good	149 (29.2)
Fair	204 (40.0)
Poor	84 (16.5)
<i>Overall genetic/genomic knowledge (n = 509)</i>	
Excellent	8 (1.6)
Very good	53 (10.4)
Good	128 (25.1)
Fair	209 (41.1)
Poor	111 (21.8)
<i>Heard or read the Essential Nursing Competencies (n = 508)</i>	
Yes	166 (32.7)
No	342 (67.3)
<i>Genetics course since licensure (n = 508)</i>	
Yes	184 (36.2)
No	324 (63.8)

Table 4

Twelve items included in total knowledge score.

Item number	Item	Correct, n (%) [†]	Incorrect, n (%) [†]
1	A family history that includes only first-degree relatives such as parents, siblings and children should be taken on every new patient	120 (27.1)	322 (72.9)
2	A family history that includes second- and third-degree relatives such as grandparents, aunts, uncles and cousins should be taken for every new patient	299 (67.6)	143 (32.4)
3	Family history-taking should be a key component of nursing care	369 (83.5)	73 (16.5)
4	There is a role for nurses in counseling patients about genetic risks	364 (82.4)	78 (17.6)
5	Do you think that genetic risk (e.g., as indicated by family history) has clinical relevance for breast cancer?	438 (99.1)	4 (0.9)
6	Do you think that genetic risk (e.g., as indicated by family history) has clinical relevance for colon cancer?	433 (98.0)	9 (2.0)
7	Do you think that genetic risk (e.g., as indicated by family history) has clinical relevance for coronary heart disease?	437 (98.9)	5 (1.1)
8	Do you think that genetic risk (e.g., as indicated by family history) has clinical relevance for diabetes?	438 (99.1)	4 (0.9)
9	Do you think that genetic risk (e.g., as indicated by family history) has clinical relevance for ovarian cancer?	426 (96.4)	16 (3.6)
10	Extent to which family history supports clinical decisions (such as administering drugs prescribed)	317 (71.7)	125 (28.3)
11	The DNA of sequences of two randomly selected healthy individuals of the same sex are 90–95% identical	158 (35.7)	284 (64.3)
12	Most common diseases such as diabetes and heart disease are caused by a single gene variant	174 (39.4)	268 (60.6)

Response frequencies restricted to 442 participants included in total knowledge score.

[†] Represent the total number (n) of participants and the percentage of participants that answered the question correctly or incorrectly. Each knowledge question was transformed into categorical variables with two possible responses, correct or incorrect.