Exploring the Capacity of Practicing Registered Nurses for Precision Health

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Article

Abstract

Precision Health (PH), a novel approach to care provision, tailors medical decisions, interventions, and treatments to an individual's uniqueness by recognizing individual variations in genes, environment, and lifestyle. Although the implementation of PH is proliferating, there is currently no clear shared understanding of it among practicing Registered Nurses (RNs). This descriptive cross-sectional study assesses nursing's capacity to integrate PH into practice through a survey examining knowledge, skills, and attitudes (KSAs) in a sample of RNs. Pilot testing of the Precision Health Nurse Capacity Scale (PHNCS) was aimed at determining its utility in assessing nurses' capacity for PH. Results indicate that nurses favor PH and that the PHNCS is a valid and reliable tool. Knowledge gains will be deployed in a nationwide survey of nurses in which the aim is to measure the capacity of the nursing workforce for both PH and genetics/genomics.

Key Words: Competencies, capacity, workforce, KSA, Genomics, Genetics, Wearables, Direct-to-consumer testing (DTCT), Social Determinants of Health (SDoH), Health Literacy, Biomarkers, omics

Precision Health (PH), an emergent phenomenon, takes a holistic approach to wellness and medical care, considering many characteristics of the individual seeking care. Cognizant of variations in genes, environment, health literacy, and lifestyle on an individual's health outcomes, PH integrates various omics information, including genomic, proteomics, metabolomics, and microbiomics, alongside clinical data to enable personalized disease diagnosis, treatment, and prevention strategies (Ginsburg & Phillips, 2018; National Research Council, 2011).

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Although the adoption, hence the visibility, of PH by institutions and individual providers is rising steeply, a shared understanding of what constitutes good practice or defined competencies is needed. The training nurses receive in PH varies widely across nursing programs and health organizations, leading to a vague understanding of what PH is, often blurring it with only the more familiar concepts and skills from genomics.

Existing literature on workforce capabilities in PH often focuses on specific subsets of care, such as genetics and genomics (Calzone et al., 2011), or specific skill sets, such as direct-to-consumer testing (DTCT) (McGrath et al., 2019). Additionally, previous literature has explored competencies in related fields, such as pharmacogenetics for pharmacists (Formea et al., 2018), radiology education with AI integration (Duong et al., 2019), and genetics and genomics for advanced practice nurses (Flowers et al., 2019). However, these studies fail to comprehensively address the baseline PH capacity of a workforce or how to integrate PH competencies into practice. This study seeks to fill that gap by surveying the capacity of a sample of Registered Nurses (RNs) to integrate PH KSAs into their practice.

This pilot study had two purposes. First, to assess the capacity of a sample of nurses to integrate precision health (PH) competencies into their practice. Second, to evaluate an investigator-developed instrument–the Precision Health Nurse Capacity Scale (PHNCS)--for its suitability in making such an assessment.

Background

The concept of PH is rooted in the Human Genome Project (2003), which provided a comprehensive map of the human genome and deepened our understanding of genetic factors contributing to diseases. Since then, research in PH has expanded with new discoveries and advancements in innovative technology and increased access to patient health data, often through giant data sets from an institution's Electronic Medical Record, or EMR. PH has evolved from the concept of Precision Medicine (PM), formerly known as personalized medicine, by incorporating omics data and considering broader factors such as lifestyle, social determinants, economic factors, cultural influences, and environmental considerations (Fu et al., 2020). Data analytics derived from these enormous data sets enable optimizing disease diagnosis, treatment, and prevention strategies tailored to each patient's needs. By integrating omic information into precise care, healthcare professionals gain a holistic understanding of an individual's biological makeup and their encompassing genetic, molecular, and microbial factors. This comprehensive approach allows for personalized interventions that optimize disease diagnosis, treatment selection, and prevention strategies, ultimately aiming to provide precise, customized care that maximizes therapeutic efficacy and improves overall health outcomes.

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Despite the potential of PH to improve care processes and outcomes, its practical application in nursing practice remains a challenge. Nurses' training and education in PH vary widely across nursing programs and health organizations, hindering the widespread implementation of PH principles in patient care. Standardized education and integrating PH competencies into nursing practice are essential for providing high-quality, personalized care—the type of care the profession has discussed for decades.

Nurse leaders are responsible for providing the necessary education and training for their workforce to apply this knowledge of omic data, SDoH, and other factors that contribute to the well-being and health of individuals. Incorporating PH principles into nursing education, including the social drivers of health, lifestyle factors, comorbidities, biomarkers, socioeconomic status, health literacy, and genetic and other omic factors, enables practitioners to effectively contribute to personalized, precise care and improved health outcomes. Additionally, ongoing professional development programs are crucial to keep nurses updated with the latest advancements and practices in the rapidly evolving field of PH. Our workforce must be ready to participate in population-based screening, targeted treatment interventions, DTCT, and other healthcare initiatives that may have a significant impact on the health of patients and populations.

Methods

Design

A cross-sectional descriptive design with convenience sampling was used to report levels (or relevance) of PH KSAs perceived by practicing nurses. Ethics approval from a university was obtained prior to data collection (IRB Approval-IRB-FY2023-169). The IRB approval and study materials were sent to four institutions in anticipation of the participation of their nurse employees.

Sampling

The target population for this pilot study is practicing RNs from across the United States. For convenience sampling, RNs working in four institutions where investigators work in four different states, California, Alabama, Pennsylvania, and New Jersey were chosen. These four sites represent varied RN experiences in PH from small community settings to large medical centers located in urban, rural, or metropolitan areas.

Instrument

The PHNCS questionnaire comprised of nine Likert-scale items formatted in a matrix-style survey (See Figure 1). These matrices were purposefully designed to align with the five domains of the familiar, person-centered nursing process: assessment, diagnosis, planning, implementation, and evaluation. These domains highlight the KSAs nurses must possess to execute their roles and responsibilities regarding this novel approach to highly individualized and data-based care.

The PHNCS questionnaire comprises nine Likert-scale items formatted in a matrix-style survey

Three of the nine questions, 1, 8, and 9, have a five-point Likert scale with scores ranging from 1 = very important to 5 = not at all important. These questions relate to the nurses' knowledge of PH principles. Questions 2, 3, 4, and 5 have a three-point Likert scale with scores ranging from 1 = advantageous to 3 = not advantageous. These items seek the nurses' beliefs on the benefits of PH in their practice, while Question 7, using the same three-point Likert scale, queries the nurses' beliefs on PH integration to the patient's care plan. Lastly, question 6, another three-point Likert scale (1 = confident and 3 = not confident), explores the nurses' confidence in using non-traditional diagnostic procedures in providing more personalized care.

Figure 1. The Precision Health Nurse Capacity Scale

The PHNCS is categorized following the nursing process domains (assessment, diagnosis, planning, intervention, and evaluation).

ASSESSMENT: *The following questions are related to the nurse's role in the systematic collection of information from/about the client.*

1. How important do you think it is for a nurse to become more educated about the following in order to provide highly individualized care?	
Social Determinants of Health	• Very important • Somewhat important • I don't know/I am not sure • Not very important • Not at all important
Direct-to-Consumer Tests	• Very important • Somewhat important • I don't know/I am not sure • Not very important • Not at all important
Wearables	• Very important • Somewhat important • I don't know/I am not sure • Not very important • Not at all important
Health literacy	• Very important • Somewhat important • I don't know/I am not sure • Not very important • Not at all important

2. Indicate whether you think each of the following would benefit by integrating assessments of *Social Determinants of Health* into your practice.			
	Advantageous	Not sure	Not advantageous
Understanding of an individual's wellness history			
Understanding of individual's potential lifestyle risk factors			
Understanding of how to help the individual			
Providing better treatment			
Understanding of individual's barriers to wellness			

3. Indicate whether you think each of the following would benefit by integrating assessments of other diagnostic procedures such as *wearables* into your practice.

	Advantageous	Not sure	Not advantageous
Understanding of an individual's wellness history			
Understanding of individual's potential lifestyle risk factors			
Understanding of how to help the individual			
Providing better treatment			

4. Please indicate whether you think each of the following would benefit by integrating assessment of other diagnostic procedures such as *direct-to-consumer test kits* into your practice.

	Advantageous	Not Sure	Not advantageous
Understanding of an individual's wellness history			
Understanding of individual's potential lifestyle risk factors			
Understanding of how to help the individual			
Providing better treatment			

5. Please indicate whether you think each of the following would benefit by integrating the assessment of an individual's *health literacy* into your practice.

	Advantageous	Not Sure	Not advantageous
Evaluate health literacy and its relation to the general well-being of a person and the community			
Describe the importance of health literacy in achieving optimum wellness.			

DIAGNOSIS: *The following questions are related to the nurse's role in clinical judgment to the client's potential or actual health conditions.*

6. Each of the following statements relates to other diagnostic procedures that can be available to achieve precision health. By incorporating this diagnostic information, healthcare professionals are able to have more information that can inform their decisions in prescribing preventative measures and treatments. Please indicate how confident you are to do each of the following:

	Confident	Not sure	Not confident
Administration and interpretation of germline testing			
Administration and interpretation of genomic and biomarker testing.			
Interpretation of Direct-to-Consumer (DTC) testing e.g., 23andme			

Assessment and interpretation of other wearables such as Fitbit, iPhone watch, implantable cardioverter defibrillators, etc.
Using Electronic Health Record (EHR) in documenting diagnostic assessments
Use of resources to explore information or interpretation of the data.
Advocating the use of precision health diagnostics

PLANNING: *The following questions are related to the client's plan of care developed by nurses.*

7. Please indicate whether you agree or disagree with the following statements.			
	Agree	Don't know	Disagree
Formulate a plan of care respectful to patient's rights including in the provision of informed consent.			
Formulate a plan of care inclusive of the client's environmental, cultural, religious, gender, and ethnic perspectives.			
Formulate a plan of care addressing the Social Determinants of Health			
Develop a plan of care with consideration to potential psychological and emotional impact from health information discovered from the client and other diagnostic findings affecting the individual and/or other family members.			
Develop a plan utilizing best practices in precision medicine or precision health			

INTERVENTIONS: *The following questions are related to the nurse's role in the implementation of nursing care.*

8. Thinking about how nurses support clinical decisions by way of those interventions, how important do you think each of the following should be performed by nurses?	
Familiarize oneself by learning and applying basic concepts and skills related to precision health/precision medicine and genomics.	• Very important • Somewhat important • I don't know/I am not sure • Not very important • Not at all important
Provide education for clients relative to precise care that promotes better lifestyle and health choices based on remotely acquired data (i.e., wearables)	• Very important • Somewhat important • I don't know/I am not sure • Not very important • Not at all important

Discern risks versus benefits when implementing precision health activities, e.g., accessing and using the patient portal as it relates to client privacy and confidentiality	• Very important • Somewhat important • I don't know/I am not sure • Not very important • Not at all important
Use patient information to develop highly personalized health care plans that aim to improve health care outcomes	• Very important • Somewhat important • I don't know/I am not sure • Not very important • Not at all important
Refer clients to appropriate resources for precision health such as interpreting genetic results, advising for treatment options, and consulting with social support organizations that can assist with social determinants of health.	• Very important • Somewhat important • I don't know/I am not sure • Not very important • Not at all important
Collaborate with other health professionals (such as physicians, pharmacists, genetic counselors, and social workers) to provide a comprehensive plan of care based on the individual's data	• Very important • Somewhat important • I don't know/I am not sure • Not very important • Not at all important

EVALUATION: *The following questions are related to the nurse's role in the continuous assessment and modifications of the plan of care.*

9. In providing continuous quality care to patients how important are the following for nurses to perform?

Reflect and evaluate one's own beliefs and biases to achieve highly individualized care for health, wellness, and improved outcomes for clients and their families.	• Very important • Somewhat important • I don't know/I am not sure • Not very important • Not at all important
Evaluate and improve the plan of care by giving full consideration to the client's Social Determinants of Health.	• Very important • Somewhat important • I don't know/I am not sure • Not very important • Not at all important
Evaluate and modify the plan of care by utilizing Precision Medicine/Precision Health advances (such as wearables).	• Very important • Somewhat important • I don't know/I am not sure • Not very important • Not at all important
Evaluate and improve the plan of care by utilizing genomic information.	• Very important • Somewhat important • I don't know/I am not sure • Not very important • Not at all important
Evaluate the plan of care to optimize the client's and their families' health literacy.	• Very important • Somewhat important • I don't know/I am not sure • Not very important • Not at all important

Data Collection and Analysis

The consent and the survey were sent to practicing registered nurses via email after permission of the facilities' IRB and nursing leaders were obtained electronically. The respondents completed the survey online and submitted it anonymously to a password-protected cloud folder. The data and the reliability of the scale were analyzed using SPSS version 27.

Results

The demographics of the study participants were not collected. Instead, the descriptors of the nursing workforce for both of the participating institutions are reported in the aggregate. One group of participants worked at a large academic medical

center in the eastern part of the United States that employs 3,555 RNs. This group consisted of primarily female (86%) nurses who are predominantly prepared at the baccalaureate and master levels (94.46%). Most nurses (70%) reported their ethnicity as White/not Hispanic or Latino, with the second most frequent category (12%) being Asian, not Hispanic/Latino. The RNs ranged in age from 22-77 years old, with an average age of 38.2 years.

In contrast, most practicing nurse respondents are employed at a local community hospital or regional medical center while also teaching at a public university Department of Nursing (DON). Their demographics represent a more diverse group of nurses, with (36.3%) Caucasians, (20.5%) Asians, (20.5%) Hispanics, (13.6%) African-Americans, and (9%) categorized as "other". They are primarily females (79.54%) with age distribution ranges from 30 to over 70 years old and an average age of 51. Most nurses (79.5%) were prepared at the graduate and doctoral levels.

Frequencies

Findings show that most nurse respondents, 84.6%-96.15%, felt it is essential for nurses to be educated about social determinants of health (SDOH), DTCT, wearables, and health literacy to provide highly individualized care – Precision Health (Table 1). Most respondents (92.31% to 96.15%) feel it is advantageous for nurses to assess a person's SDOH to understand their wellness history, potential lifestyle risk factors, means of helping the individual, and provide better treatment (Table 2). Many of the respondents consider the integration of assessments from wearables as a positive contributor to a nurse's understanding of a patient's wellness history (73.08%), potential lifestyle risk factors (80.77%), and in the provision of appropriate nursing interventions (80.77%) and better treatment (88.46%) (Table 3).

Table 1. *Importance of Establishing Nurses' Knowledge and Competencies with Precision Health*

	SDoH		DTC		W		HL	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Very important	21	80.77	11	42.31	13	50.00	24	92.31
Somewhat important	4	15.38	13	50.00	9	34.62	1	3.85
I don't know / I am not sure	1	3.85	2	7.69	4	15.38	1	3.85
Not very important	0	0.00	0	0.00	0	0.00	0	0.00
Not at all important	0	0.00	0	0.00	0	0.00	0	0.00

Note. Social Determinants of Health (SDoH), Direct-to-Consumer Tests (DTC), Wearables (W), Health literacy (HL).

Table 2. *Importance of Understanding SDoH in PH*

	WH		LRF		PoC		BT	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Advantageous	25	96.15	25	96.15	25	96.15	24	92.31
Not sure	1	3.85	1	3.85	1	3.85	2	7.69
Not advantageous	0	0.00	0	0.00	0	0.00	0	0.00

Note. Wellness history (WH), Lifestyle Risk Factors (LRF), Plan of Care (PoC), and Better Treatment (BT)

Table 3. *Importance and Utility of Wearables in Precision Health*

	WH		LRF		PoC		BT	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Advantageous	19	73.08	21	80.77	21	80.77	23	88.46
Not sure	7	26.92	5	19.23	5	19.23	3	11.54
Not advantageous	0	0.00	0	0.00	0	0.00	0	0.00

Note. Wellness history (WH), Lifestyle Risk Factors (LRF), Plan of Care (PoC), and Better Treatment (BT).

Further, most respondents consider the integration of assessments from DTCT as a positive contributor to a nurse's understanding of a patient's wellness history (69.23%), potential lifestyle risk factors (73.08%), and in the provision of appropriate nursing interventions (73.08%) and better treatment (80.77%) (Table 4). Many respondents reported that they favored an evaluation of the patient's health literacy as a contributor to the person's general well-being and optimal wellness (92.31%) (Table 5).

Table 4. *Importance and Utility of Non-Traditional Diagnostic Tests in Precision Health*

	WH		LRF		PoC		BT	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Advantageous	18	69.23	19	73.08	19	73.08	21	80.77
Not sure	7	26.92	5	19.23	6	23.08	4	15.38
Not advantageous	1	3.85	2	7.69	1	3.85	1	3.85

Note. Wellness history (WH), Lifestyle Risk Factors (LRF), Plan of Care (PoC), Better Treatment (BT).

Table 5. *Importance of Patient's Health Literacy Relative To Individual Well-Being*

	HL		HW	
	Frequency	%	Frequency	%
Advantageous	24	92.31	24	92.31
Not sure	2	7.69	2	7.69
Not advantageous	0	0.00	0	0.00

Note. Health Literacy (HL), Health and Wellness (HW).

In reporting about self-confidence in the use of non-traditional diagnostic tests, many of the respondents did not express confidence in administering and interpreting germline testing (15.38%), genomic and biomarker testing (23.07%), DTCT results (34.62%), and other wearables (50%) (Table 6). However, the vast majority of respondents expressed confidence in documenting diagnostic assessments within the EHR (92.31%), a smaller majority (76.92%) expressed confidence with the use of resources to explore information or interpret data, and a minority of respondents (46.15%) were confident in advocating for the use of PH diagnostics. Table 7 shows the percentage of respondents affirming statements related to the formulation of a precise plan of care that is: respectful of the patient's rights (88.46%), inclusive of a client's perspectives (84.62%), and of the patient's SDOH (84.62%), considerate to potential psychological and emotional impact from health information discovery (88.46%), and intentional to development of a plan reflecting best practices in Precision Medicine or PH (88.46%).

Table 6. *Confidence in Non-Traditional Diagnostic Procedures*

	GT		GBT		DTC		Wearables		EHR		Oth. Sources		Advocacy	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Confident	4	15.38	6	23.07	9	34.62	13	50.00	24	92.31	20	76.92	12	46.15
I don't know / I am not sure	12	46.15	10	38.46	9	34.62	10	38.46	1	3.85	4	15.38	11	42.31
Not confident	10	38.46	10	38.46	8	30.77	3	11.54	1	3.85	2	7.69	3	11.54

Note. Germline Testing (GT), Genomic and biomarker testing (GBT), Direct-to-Consumer (DTC), Electronic Health Record (EHR), and other sources of data (Oth. Sources).

Table 7. *Affirmation Statements When Designing a Plan of Care*

	I.Consent		Inclusive		SDoH		Holistic		EBP	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Agree	23	88.46	22	84.62	22	84.62	23	88.46	23	88.46
Don't know	3	11.54	4	15.38	4	15.38	3	11.54	3	11.54
Disagree	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00

Note. Informed Consent (I.Consent), Inclusive plan of care (Inclusive), Social Determinants of Health (SDoH), and Evidence-Based Practices (EBP)

Regarding the knowledge and skills necessary to implement precise nursing care, respondents affirmed the importance of the need for possession of basic PH principles (96.15%), the provision of precise patient education based on individual lifestyle and remotely-acquired data (96.15%), discernment of risks versus benefits in implementation of precise health activities, (96.15%), use of patient information to develop highly-personalized health plans (96.15%), patient referral to resources such as genetic counseling (96.15%), and collaboration with all health professionals to develop a precise plan of care (96.15%) (Table 8). In the evaluation of patient care, Table 9, notes that many respondents considered these factors to be very or somewhat important to the continuous quality of care: reflection on one's own beliefs (92.3%), plan improvement based on significant consideration of the patient's SDOH (96.15%), plan modification based on advances in Precision Medicine (92.3%), modification of a plan based on genomics (78.46%), and evaluation of the plan of care aimed at building health literacy (96.15%).

Table 8. *Importance of PH in Nursing Interventions*

	PH Familiarity		EduClients		RisksV.Benefits		PreciseCareplans		Referral		Collaborate	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Very important	21	80.77	18	69.23	18	69.23	23	88.46	22	84.62	24.00	92.31
Somewhat important	4	15.38	7	26.92	7	26.92	2	7.69	3	11.54	1.00	3.85
I don't know / I am not sure	1	3.85	1	3.85	1	3.85	1	3.85	1	3.85	1.00	3.85
Not very important	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0.00	0.00
Not at all important	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0.00	0.00

Note. Precision Health (PH), education for clients (EduClients), risks versus benefits (RisksV.Benefits)

Table 9. *Importance of Precision Health in the Evaluation of Care*

	ReflectOwn		EvalSDoH		ModifyPlan		UseGenomics		EvalHealthLiteracy	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Very important	22	84.62	22	84.62	17	65.38	13	50.00	22	84.62
Somewhat important	2	7.69	3	11.54	7	26.92	10	38.46	3	11.54
I don't know / I am not sure	2	7.69	1	3.85	2	7.69	3	11.54	1	3.85
Not very important	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Not at all important	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00

Note. Reflect own beliefs (ReflectOwn), evaluate Social Determinants of Health (EvalSDoH),

Validity & Reliability of the Scale

A team of experts drafted the survey questions based on a preliminary set of competencies developed by a Work Group convened by the American Nurses Association (ANA). These competencies were written in concert with practicing nurse experts in various areas of expertise within PH.

To establish face validity, the lead investigators presented the items and their scales to three practicing PH nurse experts. The items were read to them on a virtual call at which time, feedback on the relevance, wording, and timeliness of each item was received.

These three experts are employed in institutions known for innovations in personalized care. One is a Clinical Nurse Specialist in Gastrointestinal Oncology in one of our nation's premier medical centers. Another is an Associate Professor in Nursing Informatics at a school affiliated with a well-known academic medical center. The remaining expert is a staff nurse and manager in inpatient oncology at a large medical center.

The reliability of the scale was established, using Cronbach's alpha. Scores ranged from 0.78 to 0.97 which demonstrated strong measures of reliability (see Table 10).

Table 10. *Reliability of Precision Health Nurse Capacity Scale (PHNCS)*

Items	Cronbach's α
Importance to Become Educated	0.78
Social Determinants	0.94
Other Diagnostic Procedures: Wearables	0.86
Other Diagnostic Procedures: Direct-to-Consumer Test Kits	0.93
Assessment of Individual's Health Literacy	1.00
Informed Decisions in Diagnosing Patient Conditions	0.88
Plan of Care Developed by Nurses	0.97
Implementation	0.95
Continuous Assessment	0.84

Correlations

Correlations demonstrate relationships amongst variables. In this study, findings showed moderate to strong correlations between the importance for nurses to become educated with SDOH (0.73**) and the implementation (0.70**) and evaluation of patient care (0.68**). Assessment of SDOH suggested a strong relationship between nursing interventions (0.75**) and evaluation of the patient's plan of care (0.69**). The plan of care developed by nurses revealed a strong relationship with the implementation of nursing interventions (0.70**) and evaluation of patient care (0.83**). These relationships are depicted in Table 11.

Table 11. *Correlations*

	1	2	3	4	5	6	7	8	9
1. Importance to Become Educated	-	0.73**	0.33	0.29	0.38	0.26	0.47*	0.70**	0.68**
2. Social Determinants		-	0.53**	0.29	0.66**	0.08	0.52**	0.75**	0.69**
3. Other Diagnostic Procedures: Wearables			-	0.46*	0.38	0.08	0.13	0.27	0.31
4. Other Diagnostic Procedures: Direct-to-Consumer Test Kits				-	0.18	0.17	-0.01	0.16	0.26
5. Assessment of Individual's Health Literacy					-	0.12	0.33	0.50**	0.43*
6. Informed Decisions in Diagnosing Patient Conditions						-	0.20	0.18	0.30
7. Plan of Care Developed by Nurses							-	0.83**	0.70**
8. Implementation								-	0.88**
9. Continuous Assessment									-

Note. ** $p < 0.01$, * $p < 0.05$.

Discussion

Nurses responding to the pilot study overwhelmingly agreed that the workforce must be prepared to assess individual-level patient data derived from histories, laboratory results, genetic/genomic testing, and environments. They also supported the incorporation of genetic/genomic data, health histories, and data sourced from wearable devices into patient diagnoses, care planning, and interventions. Many of the nurses believed that social determinants of health (including issues of gender, culture & ethnicity, environment, & religious beliefs), along with the assessment of lifestyle risk factors, play key roles in the individualized planning of nursing interventions that meet patients' individual needs and improve patient outcomes. They also agreed that assessing patient health literacy levels impacts patient outcomes and patient/family teaching, and should play a role in the nurse's planning, interventions, and evaluation of outcomes.

A number of nurses had less confidence in their ability to administer and interpret results from diagnostic procedures such as germline and biomarker testing, although they felt competent to incorporate the results into patients' electronic medical records. Their lower confidence in interpreting the results of PH diagnostics impacts their ability to advocate for the use of these non-traditional diagnostic tools that can better contribute to a holistic plan of care.

Despite the nurses' beliefs that the KSAs identified are critical in providing precise care, their confidence in integrating diagnostics and interventions to adopt these practices is lacking. Therefore, nursing needs to teach these essential skills as the fundamental step in the full adoption of PH. A set of competencies, also lacking, is needed to guide nurse educators and other leaders in teaching and implementing PH. The seminal work presented here is merely the beginning of a multistep effort to advance PH in nursing. An important next step is the concurrent nationwide project under the auspices of the American Nurses Association (ANA) – a larger survey, "Precision Health and Genomics" (closed, July 2023) (Gelinas, 2021). PH competencies, informed by this larger survey, should appear in ANA's *Nursing: Scope and Standards of Practice* as early as 2025.

Additionally, the PHNCS, proven to have face validity and reliability, was noted to be an appropriate scale to assess the KSA of nurses relevant to PH. This scale can be used in addition to the Genetic and Genomics in Nursing Practice Scale (GGNPS) to assess the nurses' KSAs on a larger scale.

Implications for Practice

Professional nursing practice, rooted in quality and safety for cohorts of consumers or disease-based populations, has not been able to give truly-individualized care due to a lack of data and information about people, their genes, and their environment that now exist. Entraining an individual's factors into a plan of care will be every nurse's responsibility, irrespective of the practice arena. Full adoption of PH will depend upon the profession's ability to embrace this healthcare evolution, seizing the chance to transform nursing practice and inspire patient engagement in all clinical encounters to improve outcomes. Nursing education must respond to the inevitable massive cultural change necessitated by this conversion to PH or the profession will be outperformed by other providers who are both willing and ready to lead.

Future research should target the underpinnings of this lack of knowledge and/or confidence. That is, while this survey provides some answers to how nurses feel about the integration of PH and its benefits, further exploration of underlying hesitancies e.g., higher workload, inability, or unwillingness to "learn new things", feasibility issues in training, or a belief in the predominance of medical (as opposed to interprofessional) approaches to care provision is needed.

Limitations

The study limitations include common ones such as a small sample size, the cross-sectional design, convenience sampling strategy, and poor response rate. Out of the four sites targeted, only nurses from two sites participated. Application of the findings to nursing education and practice more globally necessitates a larger, nationwide sampling.

Conclusion

The adoption of Precision Medicine and Precision Health has been a remarkable step forward in providing targeted therapies to individual patients

The adoption of Precision Medicine and Precision Health has been a remarkable step forward in providing targeted therapies to individual patients based on the patient's own genetic and genomic markers. Incorporating this genetic data with information on the individual patient's SoDH and environmental factors, as well as digital data from wearables, has given healthcare providers the means to deploy digital therapeutics on an individual level. This ability has already shown great promise in treating patients as individuals rather than as a group of persons with the same medical diagnosis (Gelinas, 2021).

National and global initiatives have undertaken the necessary research to implement precision health which will improve health (Ginsberg, et al., 2018). To put this valuable research into practice, nurses must have the requisite knowledge and understanding of PH that will enable them to provide quality patient care that leads to positive outcomes and enhanced patient safety. The emerging art and science of PH call for nursing educational programs that will set standards for minimum nursing competencies and provide the necessary knowledge for both the beginning and the advanced practice nurses (Gelinas, 2021).

A healthy start is found in the establishment of baseline KSAs of nurses about PH, genetic/genomic data, and other non-traditional sources of data which are critical to the design of comprehensive curricula in all levels of nursing education. the information derived from the use of the PHNCS will form the basis for the necessary PH curriculum development, and thus allow nurses to assess, diagnose, plan, intervene, and evaluate the outcomes for their patients more accurately.

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