Leadership Strategies for Genomics Integration: A Descriptive Study Using the Canadian Adaptation of the Genetics and Genomics Nursing Practice Survey

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Abstract
The demand for genomic services that improve disease prevention, early detection and safer treatments has already outpaced the capacity of the current system. Nursing leadership strategies are urgently needed to integrate genomic discoveries into education and practice. Using findings from the national Canadian Adaptation of the Genetics and Genomics Nursing Practice Survey completed by 1,012 Canadian nurses, we recommend leadership strategies to build conducive practice environments and assist nurses in developing genomic literacy and confidence to fully participate in the integration of genomics into education and practice. Collaboration across the domains of nursing practice can generate sustainable strategies that assist nurses to be full participants in interdisciplinary teams.

Introduction

Globally, approximately 60 million people will have their genome sequenced by 2025, and these results will be used to inform their healthcare (Government of Canada 2022; WHO 2022). In Canada, it is predicted that by 2030, pharmacogenomics will be a standard practice, there will be a human genome library, the genome will be integrated into the electronic health record and genomics will be a primary vehicle for health equity (CIHR 2022). There are established risk management recommendations for diseases such as hereditary breast and ovarian cancer, Lynch syndrome and familial hypercholesterolemia (NCCN 2024), which require expanded health services to meet the needs of patients and their families (Dragojlovic et al. 2023). With a well-structured health system and a genomically literate workforce, genomic applications can improve early detection, disease prevention, individualized treatment, patient safety and health outcomes and reduce health disparities (Hesse-Biber et al. 2023; Roberts and Allen 2024; Scott et al. 2022). To ensure equitable access to genomic services, the specialist and non-specialist genomics workforce must expand (Carpenter-Clawson et al. 2023; Dragojlovic et al. 2023; Green et al. 2020; Thomas et al. 2023).[1]

There have been repeated calls to support nurses to develop genomic literacy, yet the integration of genomics remains a global nursing challenge (Calzone et al. 2013; Thomas et al. 2023). Therefore, to help focus Canadian efforts on workforce development and integration of genomics into nursing education and practice, we collected data on nurses' attitudes, receptivity, confidence, competency, knowledge, social systems and the decision/adoption process influencing the uptake of genomics using the Canadian Adaptation of the Genetics and Genomics Nursing Practice Survey (GGNPS-CA) (Calzone et al. 2016; Plavskin et al. 2019, 2023). The purpose of this paper is to illustrate how the GGNPS-CA data can be used by leaders to develop strengths-based strategies to accelerate genomic integration into nursing practice and support health system transformation for the genomic era.

Background

The need for specialized and mainstreamed genomics-informed healthcare is outpacing the resources in the current Canadian system (Dragojlovic et al. 2023; Husereau et al. 2023a, 2023b; Snow et al. 2024) and the uneven access to the benefits of genomics across populations is concerning (Allen et al. 2023; Gouvea 2022; Martin et al. 2022). The limited clinical adoption and barriers to accessible, equitable and safe genomics-informed care, including genetic testing, referrals, cascade testing and treatment, are structural and modifiable. Therefore, preparing the healthcare workforce to equitably integrate genomics can lead to health system transformation and address health disparities (Husereau et al. 2022; Khoury et al. 2022; Limoges et al. 2024a). With a current global workforce of 27.9 million nurses working across diverse practice settings (WHO 2020), nurses with genomic

literacy are poised to enhance the equitable integration of genomics-informed practice (Clarke and van El 2022). However, many challenges impede nurses' efforts to develop genomic literacy and genomics-informed practice – even in countries considered to be leading integration efforts. In Canada, nurses report low confidence, knowledge and support to integrate genomics into practice (Dewell et al. 2020; Hébert et al. 2022; Limoges et al. 2022; Swadas et al. 2022). These results are concerning, given that Canadian nurses indicated that genomic education and workforce preparedness were key priorities for meeting patient care needs (Chiu et al. 2024b; Hébert et al. 2022; Limoges et al. 2022; Swadas et al. 2022).

Members of the public view nurses as highly trusted sources of health information (Estev and Hommel 2020; Palaz and Kayacan 2022; SteelFisher et al. 2023; Walker 2024). When equipped with genomic literacy, nurses can provide patient education, initiate appropriate referrals to specialist services, reduce service wait times and support new care pathways and models of care related to genetic testing (Barnhardt et al. 2023; McAllister and Schmitt 2015; Mordenti et al. 2023; Quinn 2023; Rauw et al. 2022). Nurses can contribute to the culturally safe collection of accurate family health histories (Williams et al. 2019) and ensure that populations have equitable opportunities to benefit from genomics-informed care (Guzauskas et al. 2023; Limoges et al. 2024a; Scott et al. 2022). Supporting nurses with concerted strategies to develop competencies at the intersection of genomic literacy, the social determinants of health and nursing practice is crucial (Gouvea 2022; Martin et al. 2022; Milani et al. 2023; Thomas et al. 2023). To support these initiatives, we required an accurate measure of Canadian nurses' attitudes, receptivity, confidence, competency, knowledge, social systems and the decision adoption process influencing the uptake of genomics into practice to guide implementation efforts. Thus, we conducted a national survey to generate benchmark data to ensure that initiatives align with nurses' strengths and areas that are most important to them.

Methods

Survey Instrument and Variables

We used the GGNPS-CA, a Canadian-specific adaptation of the GGNPS (Genetics and Genomics Nursing Practice Survey) (Calzone et al. 2016; Plavskin et al. 2019, 2023). Permission was obtained from the original author to use and modify the GGNPS. The original GGNPS is a validated, reliable tool (Calzone et al. 2016; Plavskin et al. 2019, 2023) and measures variables of interest embedded in the Canadian Nursing and Genomics Engagement Framework (Canadian Nursing and Genomics 2022; Limoges et al. 2022). GGNPS-CA variables include nurses' attitudes, receptivity, confidence, competency/knowledge, social systems and the

decision/adoption process (Calzone et al. 2016; Plavskin et al. 2019, 2023). The conceptual and operational definitions for the survey variables linked to specific measurement items on the GGNPS scale were previously described (Calzone et al. 2013). The GGNPS has been used across different countries and has been translated into Turkish (Yeşilçinar et al. 2022) and Chinese (Zhao et al. 2022).

To adapt the GGNPS to reflect the Canadian context, we added 13 new questions (Table 1) to the 60-item GGNPS (Calzone et al. 2016; Plavskin et al. 2019, 2023) and the phrase "common health diseases" was altered to the preferred Canadian terminology of "common health challenges." Seven of the 13 new questions relate to equity and were informed by the scholarly literature describing the social impact of genomics and the uneven benefits from genomics-informed care and by the expertise of the research team. The other six questions reflect the Canadian health context and the expanded uses of genomic testing in fields such as mental health. New questions were added as no existing instrument overtly measured nurses' knowledge and confidence in the equitable and ethical delivery of genomic services in healthcare (Laaksonen et al. 2023). The face and content validity of the adapted tool were established with a sample of 10 nurses who were recruited from the research team's professional networks. These nurses were from clinical practice, education, research and administration, and had expertise or familiarity in genomics research or genomics in nursing education or practice. Modifications on the new items were made based on their feedback. The GGNPS-CA uses multiple response methods, including "select all that apply," pick lists, multiple choice, yes/no, true/false and Likert scales, similar to the original GGNPS (Calzone et al. 2016; Plavskin et al. 2019, 2023). Twelve items on the original GGNPS measure genomic knowledge and were combined to calculate a knowledge score (KS) (Calzone et al. 2016). Thirteen items measure confidence, and these individual questions were used to calculate an overall confidence score (CS) ranging from 0 to 13. Higher scores indicate greater knowledge and confidence to deliver genomic-informed care. Eight demographic questions were used to describe the sample.

Design and Ethical Considerations

We used a cross-sectional descriptive study approved by the Athabasca University's and Memorial University's research ethics boards (file #24876 and #2022.151). Registered nurses, licensed practical nurses, registered practical nurses, registered psychiatric nurses and nurse practitioners from across Canada were invited to participate in the online survey on REDcap through an e-mail from provincial nursing regulatory bodies, professional associations, academic institutions and the professional networks of the researchers. All Canadian regulatory colleges/associations for all nursing designations were approached by the

Table 1. New questions added to the GGNPS-CA

Stem	Additional items
Please indicate whether you think each of the following would be a potential advantage to integrating genetics of common health challenges into your practice.	Part 1 of GGNPS-CA survey: Broad attitudes on genomics 1. Identification of individuals who could be enrolled in high-risk screening programs. 2. Addressing the needs of underserved groups (those with health disparity). *Likert scale response*
	3. How important do you think it is for nurses to become more educated about the interactions between environmental exposures (e.g., early life adversities, environmental pollutants) and genes in increasing or decreasing risk of common health challenges, such as cancer, diabetes, heart disease and mental health? *Likert scale response*
	4. How important do you think it is for nurses to become more educated about the ethical issues (e.g., informed decision making) associated with genomics? *Likert scale response*
Each of the following statements relates to the genetics of common health challenges and family history taking. By common health challenges, we are referring to disorders that arise due to interactions between an individual's environment and their unique genetic makeup. Common health challenges include cancer, heart disease, diabetes and mental health. Please indicate how confident you are that you can do each of the following:	Part 2 of the GGNPS-CA survey: Confidence and family history–specific attitudes 5. Consider access to the social determinants of health when interpreting the family history and making recommendations/referrals. 6. Engage in interprofessional collaboration when using genomics in care planning/delivery. 7. Provide culturally safe care that includes genomics. 8. Collect and interpret the family history with sensitivity for diversity, heritage and family composition. 9. Facilitate communication of genetic risk within families to support health outcomes (e.g., consider the value of genetic testing in families with a known pathogenic variant). *Not at all confident or confident*
Do you think that genetic risk (e.g., as indicated by family history) has clinical relevance for the following:	Part 4 of the GGNPS-CA survey: General genomics knowledge 10. Mental health *Likert scale response*
	Part 6 of the GGNPS-CA survey: Personal genomic competency assessment 11. Please rate your understanding of the equity issues associated with genomics. 12. Please rate your understanding of the ethical issues associated with genomics. *Response options included excellent, good and poor.*

GGNPS-CA = Canadian Adaptation of the Genetics and Genomics Nursing Practice Survey.

research team to assist with recruitment and provided an ethics-approved e-mail script and/or e-poster. There was variation in the protocols used by the colleges/associations to contact their members for research. Some allowed methods including direct e-mails to members (n = 9), e-newsletters to members (n = 3) or posts on social media pages and/or websites (n = 5); while others did not engage with their members for research; and some did not reply to our requests, which included three follow-up attempts by the research team. The highest response rates (Table 2, available online at longwoods.com/content/27467) were in provinces that distributed a survey e-mail link directly to members. We also recruited through four national professional associations/specialty interest groups and through the universities of the research team and that of our network using banners on websites and some direct e-mailing when this was allowed by the university. Before commencing the survey, participants provided informed consent through an online form. The survey and consent were provided in French and English, the official languages of Canada. Data were collected between November 2022 and February 2023.

Data Analysis

Study data were analyzed using IBM SPSS V25. Participants' demographic characteristics and responses to individual items were calculated using descriptive statistics and frequencies as appropriate. Individual item responses for the knowledge and confidence questions were calculated with frequency statistics to generate scores. The analysis was conducted with the goal of providing benchmarking data and insights to guide leadership strategies to augment implementation efforts. With the exception of the 13 new questions, the GGNPS was altered as little as possible to enable international comparisons (Calzone et al. 2013; Yeşilçinar et al. 2022; Zhao et al. 2022). A team in Finland has used a translated version of the GGNPS-CA with results forthcoming.

Results

Sample Characteristics and Response

In total, 1,397 people clicked on the consent and 1,012 completed the survey, reflecting a 72.4% completion rate; 72.3% of the total sample were nurses actively engaged in patient care. Most participants identified as female (92.6%) and white (83.3%). The majority of participants were between 31 and 50 years of age (54.5%), while the smallest proportion was over 65 (3.8%). Many participants had obtained an undergraduate degree (54.0%), and 34.9% had over 20 years of professional experience. The primary practice field varied, with the majority working in community care and/or long-term care (21.1%). Most identified as registered nurses (79.8%). There was representation from nine of the 10 Canadian provinces and two of three territories (see Table 2 for demographics).

Attitudes and Receptivity

Most nurses (91.7%) indicated that becoming more educated about the genomics of common health challenges, the interactions between environmental exposures and genes and the ethical issues associated with genomics was very or somewhat important. Nurses stated that integrating genomics could lead to advantages such as improved services (92.3%), better treatment adherence (81.9%), identification of individuals for high-risk screening (95.6%) and addressing the needs of underserved groups (87%). Furthermore, 79.4% agreed that nurses have a role in counselling patients about their genetic risk.

Knowledge Score

Participants self-ranked their genetic/genomic knowledge as excellent (1%), good (26%) and poor (73%). Only 26% of participants rated their understanding of the equity issues associated with genomics as good or excellent. The mean KS was 8.59/12 or 71.6% with a standard deviation (SD) of 1.56. Over 99% of participants correctly answered the five knowledge questions addressing the clinical relevance of genetics for common health conditions such as breast, ovarian and colon cancer; heart disease; and diabetes, which raised the KS (see Table 3 for the results of the knowledge questions).

Confidence Score

The mean CS was 5.06/13 (39%), with an SD of 4.18, indicating nurses generally lack confidence. Their confidence level varied by topic. Nurses were the most confident in considering access to the social determinants of health when interpreting family history and making recommendations or referrals (56.5%); collecting and interpreting family history with sensitivity to diversity, heritage and family composition (54.6%); and providing culturally safe care that included genomics. Nurses were the least confident in giving patients information about the limitations of genetic testing for common health challenges (24.5%), the risks of genetic testing for common health challenges (25.3%) and facilitating referrals for genetic services for common health challenges (28%).

Social Systems

Only 12.5% indicated that their managers saw genetics as an important part of their role, and 15.5% thought that senior staff saw genetics as important. Nurses (67.7%) disclosed that genetics was not part of their undergraduate curriculum. Furthermore, 90.8% had not taken a course focused on genomics post-graduation. Although 53% of nurses noted they intended to learn more about genomics, 7.3% reported they did not want to learn more and 39% disclosed that they did not know if they intended to learn more. While 53.8% of nurses indicated that they would take a course in genomics during work time, more (67.4%) preferred to do

Table 3. Knowledge items, total score and nurses' responses

Total knowledge score (8.59 ± 1.56 SD)		
	Correct answers	
Items	*n*	%
1. A family history that includes only first degree relatives such as parents, siblings and children should be taken for every new patient. (Disagree)	271	26.9%
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. (Agree)	532	52.8%
3. Family history taking should be a key component of nursing care. (Agree)	861	85.7%
4. There is a role for nurses in counselling patients about genetic risks. (Agree)	801	79.4%
5. Do you think that genetic risk (e.g., as indicated by family history) has clinical relevance for breast cancer? (Somewhat, a great deal)	1,009	99.8%
6. Do you think that genetic risk (e.g., as indicated by family history) has clinical relevance for colon cancer? (Somewhat, a great deal)	1,001	99.7%
7. Do you think that genetic risk (e.g., as indicated by family history) has clinical relevance for coronary heart disease? (Somewhat, a great deal)	1,004	99.3%
8. Do you think that genetic risk (e.g., as indicated by family history) has clinical relevance for diabetes? (Somewhat, a great deal)	998	99.0%
9. Do you think that genetic risk (e.g., as indicated by family history) has clinical relevance for ovarian cancer? (Somewhat, a great deal)	1,003	99.4%
10. What is the extent to which family history supports clinical decisions (such as administering drugs prescribed)? (Essential)	616	61.8%
11. The DNA of sequences of two randomly selected healthy individuals of the same sex is 90–95% identical. (False)	285	28.2%
12. Most common diseases such as diabetes and heart disease are caused by a single gene variant. (False)	321	31.8%

additional education on their own time. Participant responses indicated low levels of perceived support for genomics-informed nursing practice.

Decision/Adoption Process

Nurses ($N = 731$, 72.3%) who indicated that they actively provided patient care revealed that few incorporated genomics-informed practices. When asked about the past three months in practice, 62.9% of nurses indicated that they rarely or never collected a family history, including information on disorders from three generations, age at diagnosis and death. Participants (55.8%) indicated that they rarely or never used a family health history to facilitate clinical decisions or

recommendations, and 81.9% reported that they had never facilitated a referral to genetic services. In the past three months, however, 19% of respondents actively taking care of patients indicated that patients had initiated a discussion about genomics.

Discussion

International nurses leading genomic integration efforts are calling for a shift from descriptive work (often focusing on deficits in nurses' genomic knowledge and competency), to research targeted at action, intervention and outcome evaluation (Thomas et al. 2023; Tonkin et al. 2020a, 2020b). Responding to these calls and to Canadian nurses' ongoing requests for support to integrate genomics (Chiu et al. 2024a, 2024b; Limoges et al. 2022), we frame the discussion of our GGNPS-CA results to show how they can inform leadership strategies that are up-to-date, evidence-based and reflect the needs of the Canadian nursing workforce. Furthermore, our survey results were very similar to previously published papers (Calzone et al. 2013; Yeşilçinar et al. 2022; Zhao et al. 2022), and thus, we felt it would be most productive to illustrate how the survey results can generate leadership strategies to interrupt these persistent challenges. Leadership is crucial to the integration of genomics, yet specific strategies are not well articulated in the literature (Best et al. 2020; Fu et al. 2020; Kurnat-Thoma et al. 2021; Limoges et al. 2022). A defined set of nursing leadership strategies can guide the development of a workforce with genomic literacy, clarify roles and responsibilities and help to implement policies and practice changes arising from scientific advancements in genomics (Carpenter-Clawson et al. 2023; Thomas et al. 2023).

Given the large sample size, we are confident that the results of the GGNPS-CA accurately measured the nurses' attitudes, receptivity, confidence, competency/knowledge, social systems and the decision/adoption process. The results revealed strengths that can be leveraged by leaders to bolster the practice environment, bridge gaps in infrastructure that impact implementation and recognize the complexity of genomics as a knowledge form. Therefore, this discussion focuses on two main topics. The first includes leadership strategies to build conducive social systems, practice environments and policies to ensure the sustainability of efforts aimed at mainstreaming genomics across all practice domains. The second topic covers strategies to assist nurses to develop genomic literacy and confidently participate in the clinical integration of genomics into healthcare. We use strengths-based leadership (Gottlieb et al. 2012, 2021) that is rooted in principles of person-centredness, empowerment, relationships and innate capacities (strengths). This approach can facilitate nurses' autonomy, agency and collaborative relationships that allow all parties to contribute to team functioning (Gottlieb et al. 2021; Lavoie-Tremblay et al. 2024).

Leadership Strategies to Build Conducive Social Systems, Practice Environments and Policy to Support Nurses' Integration of Genomics

Research in Canada and elsewhere reveals how the lack of organizational supports (Carpenter-Clawson et al. 2023; Thomas et al. 2023), social context (Chiu et al. 2024a, 2024b; Husereau et al. 2022; Husereau et al. 2023a; Menon et al. 2019) and policy infrastructure (Puddester et al. 2023) impact the integration of genomics. Our findings highlighted a disjuncture that can be addressed through focused leadership. GGNPS-CA survey data indicate that nurses view genomics as important and want to learn more. Most nurses (99.0%) saw the relevance of genomics to common health conditions and recognized that genomics would benefit patient health outcomes. Furthermore, nurses (79.4%) identified a role in counselling patients about genetic risk and one in five nurses said that patients had initiated conversations with them in the past three months. While these results show that nurses are interested, there are challenges in that they self-ranked their knowledge as poor and identified very low confidence levels in using genomics in practice. Nurses require assistance to equip themselves with the knowledge and skills to meet patient care needs. Yet only 12.5% of nurses perceived support from managers and 15.5% perceived support from senior staff for integrating genomics into clinical care. Situations where nurses felt unsupported by leadership are not a new problem in Canada (Bottorff et al. 2005a, 2005b) or in the US (Hines-Dowell et al. 2024). Given the perceived lack of support, strengths-based leadership strategies that include collaboration between nurses who provide care to patients and their managers can help build supportive social structures that enable the integration of genomics into clinical care. Integrating a complex knowledge form such as genomics requires the dismantling of silos in practice, education, research and policy, and this takes ongoing and responsive leadership (Limoges et al. 2022).

A year-long intervention study revealed that identifying and supporting genomic champions can provide nurses with the tools, resources and a competency framework to attain genomic literacy and leadership competencies (Calzone et al. 2018). The champions influenced other nurses to learn and recognize the value of engaging with genomic practices, demonstrating that leaders impact genomics integration. Establishing a similar champion program could help develop leaders who can support others. However, based on the champion program in the US, even after a year-long intervention, leaders required ongoing support (Calzone et al. 2018) in part due to the rapid development of complex and practice-changing genomics knowledge, necessitating frequent updates and new care pathways (Calzone et al. 2018; Kurnat-Thoma et al. 2021; Smania et al. 2022; Zureigat et al. 2022). The facilitators and barriers specific to nurses' ability to sustain genomic competencies also change with new scientific discoveries, necessitating new leadership approaches to support contemporary practice changes. As such, ensuring ongoing support for champions is crucial.

Another important consideration is that leadership is optimized when coupled with the necessary infrastructure, such as policies, structured education programs and professional regulation. Recent research (Chiu et al. 2024a) indicates that robust policy can support nurses to integrate genomics and develop role clarity. The policy guidance that would support genomics-informed education and practice is lacking in Canada and must be prioritized (Puddester et al. 2023). To fill this gap, leaders can start by engaging in processes to understand the types of questions patients are asking nurses and the roles that nurses envision related to genomics. Leaders can then use specific strategies such as collaborative policy development, identifying points of intersection between existing practices and policies and intentionally developing position statements and nursing practice guidelines to drive change in education and practice (Chiu et al. 2024a, 2024b; Kurnat-Thoma et al. 2021). A Roadmap for Global Acceleration of Genomics Integration Across Nursing (Tonkin et al. 2020a) uses implementation science (Damschroder et al. 2009, 2022) and offers practical steps that can strengthen the social systems necessary for the integration of genomics.

Leading Strategies to Enhance Genomic Literacy and Confidence

Through the GGNPS-CA, nurses identified a lack of genomics content in nursing education and obtained moderate KSs and low CSs. Our findings are similar to other studies (Carpenter-Clawson et al. 2023; Gonthier et al. 2018; Hébert et al. 2022; Seven et al. 2017; Swadas et al. 2022; Yeşilçinar et al. 2022; Zhao et al. 2022), demonstrating that globally, efforts are needed to educate nurses and to support integration of genomics into practice. Without comfort and confidence in genomics, nurses have described sitting on the sidelines, feeling unsure and insecure in their ability to speak up or to bring their disciplinary perspectives to the forefront of patient care (Chiu et al. 2024b; Hines-Dowell et al. 2024). Genomics is a complex science, and this is compounded by systems challenges, including health system design, funding and the lack of standardization stemming from a weak policy infrastructure (Friedrich et al. 2024; Hines-Dowell et al. 2024; Husereau et al. 2023a; Snow et al. 2024). As the GGNPS-CA revealed, there have been limited opportunities for all nurses, including leaders, to learn about genomics. These challenges impact leaders' efforts to integrate genomics into routine nursing practice and demonstrate the need for specific leadership development for the genomic era. Supporting education for genomic literacy across all domains of nursing practice (i.e., administration, education, researchers, point of care and policy) is a crucial strategy to support genomics integration (Bashore et al. 2018; Calzone et al. 2018; Zureigat et al. 2022). Systematically designed and evaluated education using frameworks (Limoges et al. 2024b; Nisselle et al. 2021) can support rigorous research and address the current gaps in evidence-based education literature (Zureigat et al. 2022). Nurse leaders can capitalize on nurses' readiness to learn and change practice by ensuring that they have access to education to

build the knowledge and confidence to meet patient needs. Canadian Nursing and Genomics (n.d.) have developed a toolkit that provides resources to nurses in various areas of practice.

Leveraging nurses' potential contributions and their interest in learning, rather than focusing on deficits, such as low KSs and CSs, can guide leadership strategies that promote nurses' self-efficacy, agency and autonomy to provide their unique disciplinary perspective to the interdisciplinary team. For example, participants reported the highest confidence levels in delivering genomics-informed care using culturally appropriate practices (e.g., cultural safety) and collecting a family history sensitive to diversity, heritage and family composition. Yet they reported rarely collecting a family health history, revealing a practice gap. Education can build on nurses' strengths and address health disparities in genomic healthcare (Roberts et al. 2019; Yoes and Thomas 2020) so that nurses can further contribute to safe and equitable healthcare.

Nurses have demonstrated their ability to impact the utilization of and access to genomics services (Barnhardt et al. 2023; McAllister and Schmitt 2015; Mordenti et al. 2023; Quinn 2023; Rauw et al. 2022), highlighting the importance of nurses to the sustainability of the health system. Leaders can support nurses to engage in the design and implementation of interventions and encourage nurses to promote equitable and safe translation of genomics to patient care (Calzone et al. 2018; Carpenter-Clawson et al. 2023; Fu et al. 2020; Martin et al. 2022; Milani et al. 2023; Thomas et al. 2023). The ACCESS framework (Katapodi et al. 2024) embeds genomics into already established nursing practices and provides a standardized and unifying guide for education and practice change. Joining elements of the ACCESS framework with strategies that help address health disparities, including community building, standardizing patient education and clinical pathways and conducting research that promotes inclusion and equity can assist nurses to address health disparities (Limoges et al. 2024a). Nurses can be further engaged in the specialist and non-specialist genomic workforce to help address diversity, equity and access to genomic services (Patch and Middleton 2018; Scott et al. 2022; Tindale et al. 2022).

Implications for Nursing Leadership

The following leadership strategies can amplify nurses' contributions to genomics.

- Collaborate with nurses to validate their practice concerns and understand their knowledge needs and the types of questions patients are asking to co-design practice supports.
- Use strengths-based leadership to offer education programs in combination with clinical integration efforts.

- Use existing frameworks such as the roadmap (Tonkin et al. 2020a), the maturity matrix (Tonkin et al. 2020b) and the ACCESS framework (Katapodi et al. 2024) to systematically design and evaluate strategies to enhance genomic literacy and clinical integration of genomic technologies.
- Collaborate with nurses from the five domains of practice to build evidence and develop a strong policy infrastructure to support genomics-informed nursing.

Limitations

There are limitations that should be considered. Only descriptive statistics of self-reported data were used to inform the findings, discussion and recommendations. The rating of managers and senior staff support came from nurses, who self-identified as working directly with patients, and not directly from managers or senior staff. Nurses might have completed more than one survey; however, there were no inducements, and we assume each nurse completed one survey as requested in the invite. The sample may not represent all nurses. Test re-test measures were not conducted on the 13 new items that were added to the GGNPS-CA.

Conclusion

The findings from this study provide a benchmark of Canadian nurses' attitudes, receptivity, confidence, knowledge, practices and influences of social systems and equity issues in genomics. Nurses recognize the importance of genomics for patient care and require support to develop foundational knowledge and confidence to integrate it into their clinical practices. This is an urgent issue as nearly one in five nurses in this survey reported that patients had initiated conversations with them on genomics in the past three months. Prerequisites of safe, accessible and effective genomic services are genomic literacy and social systems that support the integration of genomics and changes in approaches to practice. More research is needed to understand patient needs and nurse-sensitive patient outcomes and to evaluate leadership strategies that support workforce development and the integration and delivery of genomics services. Nurses comprise over 44.0% of the healthcare workforce and are Canada's largest professionally qualified providers. Investing in strategies that increase nurses' genomic literacy and genomics-informed practices can improve access to safe and equity-based genomics care.

Leaders require foundational knowledge and an understanding of the complexities of genomics science to address the challenges associated with its integration. To strengthen nurses' participation in genomics healthcare, leaders can use strengths-based leadership strategies to foster collaboration across the domains of nursing practice, understand how nurses engage with patients who ask about genomics and build nurses' knowledge and confidence to meet patient care needs. Considering nurses' low CSs and low self-ranked KSs, leaders can target

strategies to support nurses in developing genomic literacy to ensure patient safety and access to care services. Leaders must also acknowledge the challenges faced by nurses who practise with low knowledge and confidence in genomics, given nurses' perceptions that they have a role in providing genomics services and their understanding of the advantages of genomics to patients. Leaders who consider the above-mentioned factors will support nurses as full participants in the genomics era.

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Data Availability Statement

The authors may make the data supporting this article available to other qualified researchers exploring nursing and genomics upon request.

Conflict of Interest

The authors declare that the research was conducted without any commercial or financial relationships that could be construed as a conflict of interest.

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Note

[1] The terms "genetics" and "genomics" are both used in this article. Genomics is the more current term and pertains to the study of all of a person's genes and their interactions with the environment, whereas genetics is limited primarily to single-gene conditions. However, we retain fidelity with original source material when we use the term genetics.

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