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Review

Scholarly literature on nurses and pharmacogenomics: A scoping review

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ABSTRACT

Background: Pharmacogenomics is the bioscience investigating how genes affect medication responses. Nurses are instrumental in medication safety. Pharmacogenomics is slowly being integrated into healthcare, and knowledge and understanding of it is now pertinent to nursing practice.
Purpose: This paper aims to map the scholarly literature on pharmacogenomics in relation to nurses.
Methods: A scoping review was conducted in four databases: CINAHL, Embase (Ovid), ProQuest Health and Medicine and PubMed using the search terms *pharmacogenomic**, *pharmacogenetic**, *PGx**, and *nurs**, resulting in 263 articles of which 77 articles met the inclusion criteria.
Findings: Most articles (85 %, $n = 65$) were non-empirical and 12 presented empirical data (15 %, $n = 12$). The articles were USA-centric (81 %, $n = 62$) and represented a broad range of nursing specialties.
Conclusion: The majority of scholarly literature on nurses and pharmacogenomics is narrative reviews. Further empirical research is warranted to investigate nurses' current knowledge levels and potential involvement with pharmacogenomics in clinical practice.

1. Background

Pharmacogenomics merges elements of pharmacology and genomics to investigate how genes affect medication response. The term *pharmacogenomics* is frequently used interchangeably with the term *pharmacogenetics*; however, pharmacogenomics is occasionally defined as investigating multiple gene variants while pharmacogenetics focuses on medication responses to inherited single gene variants (Australian Centre for Health Research, 2008; Cheek, 2013; Kisor et al., 2016). Pharmacogenomics is part of precision medicine and commonly referred to as the health care paradigm shift from "one size fits all" to genetically tailored disease prevention, diagnostics, and medical treatments (Kessler, 2018; Olson et al., 2017; Youssef et al., 2020). Genetics (study of hereditary and of a single gene) and genomics (study of all a humans' genes in combination, including interactions between those genes and the environment) are currently changing health care service delivery in a variety of medical specialties, evidently affecting nursing care worldwide (Calzone et al., 2018; Hickey et al., 2018; Kessler, 2018).

The corpus of data linking genes to how medications are metabolised in the body are substantial and continues to increase (Medwid and Kim, 2022; Swen et al., 2023). It is well known that medications do not have a homogenous effect on the wider population, with some individuals experiencing adverse effects and others no effect from the same treatment (Hippman and Nislow, 2019; Krebs and Milani, 2019; Polasek et al., 2019). While non-genetic factors such as diet, age, liver/renal function, and drug interactions certainly contribute towards drug responses, non-responsiveness or an adverse response to a medication may be due to a variation in the gene coding for the enzyme which metabolises that drug (Cheek and Brazeau, 2015; Polasek et al., 2019; Somogyi and Phillips, 2017). Gene variants, or alleles, differ between individuals and produce a variety of alternative responses to the same medical therapy. Several medications commonly administered by nurses, such as clopidogrel (antiplatelet therapy), warfarin (anti-coagulant therapy) and codeine (analgesia) are metabolised by the cytochrome P450 (CYP) class of enzymes which is responsible for up to 75 % of medication biotransformation (Bray et al., 2008; Cheek and Howington, 2018; Krau, 2016). As an example, codeine is a prodrug which only converts into its active metabolite (morphine) by the *CYP2D6* enzyme (Medwid and Kim, 2022). Certain variants of the *CYP2D6* enzyme do not convert codeine into morphine and thus, individuals carrying these gene variants will not experience pain relief from codeine (Kelly, 2013; Somogyi and Phillips, 2017; Ting and Schug, 2016). Conversely, if an individual has an over-

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expressive or enhanced variant of the *CYP2D6* enzyme, they will rapidly and extensively metabolise codeine into morphine and potentially experience untoward effects such as toxicity, respiratory depression, and reduced pain relief (Beery and Smith, 2011; Kelly, 2013; Smith, 2009; Somogyi and Phillips, 2017).

Studies have estimated that up to 95 % of the population carries at least one actionable genotype and pharmacogenetic-guided prescribing can reduce adverse drug events by up to 30 % (Adesta et al., 2021; Kabbani et al., 2023; Swen et al., 2023; Van der Wouden et al., 2017). These genetic variants affect drug kinetics and are referred to as "metabolic types" (Mutsatsa and Currid, 2013; Sink and Scardina, 2021). In the instance of a poorly functioning gene variant, the metabolic type is referred to as "poor metaboliser" while an over-expressive or enhanced variant is referred to as "ultrarapid metaboliser" (Olson et al., 2017; Ting and Schug, 2016). Clinical guidelines for actionable pharmacogenomic information are available online and continuously updated by committees such as the Clinical Pharmacogenetics Implementations Consortium and the Dutch Pharmacogenetics Working Group. As per January 2024 there are 200 clinical guideline annotations and more than 1000 drug label annotations available at the PharmGKB website (PharmGKB, 2024).

While there are significant barriers to the implementation of pharmacogenomic testing into standard clinical practice, initiatives are occurring worldwide (Medwid and Kim, 2022; Morris et al., 2023; Van der Wouden et al., 2017). In the US, the Vanderbilt Pharmacogenomics Resource for Enhanced Decisions in Care and Treatment Program (PREDICT) aims to provide pre-emptive pharmacogenomic tests to more than 10,000 patients, with preliminary results confirming that out of 9589 patients 91 % have more than one actionable gene variant (Krebs and Milani, 2019). The Pharmacogenomics Research network (PRGN) and the Implementing Genomics in Practice (IGNITE) networks are currently assessing how to implement pharmacogenomics into routine health care in the US (Krebs and Milani, 2019). In Europe, the Ubiquitous Pharmacogenomics Consortium (U-PGx) program investigates pharmacogenomic impact on patient outcomes as well as cost-effectiveness in seven European countries (Turner et al., 2020; Van der Wouden et al., 2017). NHS England has formed a panel to review evidence for drug-gene associations and make initial recommendations to incorporate pharmacogenomic tests into the NHS standard test directory, with key drugs discussed being codeine, clopidogrel and warfarin (Turner et al., 2020). In Asia, the South-East Asian Pharmacogenomics Research Network (SEAPharm), a collaboration between Korea, Malaysia, Thailand, Indonesia, and Taiwan, are conducting trials to map adverse events and develop guidelines for the Asian population (Krebs and Milani, 2019). As nurses comprise a significant portion of the healthcare workforce (Calzone et al., 2018), these examples of pharmacogenomic initiatives strongly suggest that nurses are likely to encounter pharmacogenomics in their healthcare setting in the near future.

Nurses are the health professionals most frequently in contact with people using health services and are at the forefront of medication administration. Nurses observe, discuss, and report medication treatment outcomes to the healthcare team, people using services, and families and their professional scope of practice requires they are alert to observe and notify adverse medication events (Blix, 2014; Mutsatsa and Currid, 2013). Pharmacogenomics introduces new knowledge for nurses regarding safer medication practices for some people and any current or future implementation of clinical pharmacogenomics will need to consider the role of nurses in the medication team (Mills et al., 2011; Morris et al., 2023; Wright et al., 2019). A preliminary review of the literature on nurses and pharmacogenomics demonstrated a scarcity of high-quality empirical research with most published literature being non-empirical. It was therefore prudent to conduct a scoping review as this methodology would capture both these forms of published literature. The aim of this review is to identify and categorize the body of evidence as it relates to nurses and pharmacogenomics, to provide an overview that will guide future research directions in this emerging field.

2. Methodology

A scoping review was conducted as this is commonly applied when the area of interest is not well researched and the literature is heterogenous and complex (Peters et al., 2015; Pham et al., 2014). The scoping review process is well suited for broad mapping of type and range of research methods, year of publications, country or author affiliation, and context, which accommodates the aim of this review (Joanna Briggs Institute, 2021; Peters et al., 2015). The review is reported in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist and Explanation (Tricco et al., 2018).

The databases searched were CINAHL (EBSCO), Embase (OVID), ProQuest Health and Medicine, and PubMed. Medical Subject Headings (MeSH) terms and keywords were initially developed using the PCC Framework (Population, Concept, Context); however, the context terms were excluded when applied in the final search strategy due to a significantly reduced result. The final search terms were (i) *nurs** and (ii) *pharmacogenomic** or *pharmacogenetic** or *PGx**. No other restrictions were used. Two consecutive searches were performed using the same search strategy. The first search was performed on June 28th, 2021, and the second on August 7th, 2023. The first search revealed 237 articles and the second search revealed 26 additional articles. The results were uploaded into Covidence (version 2)) which is a screening and data extraction tool that streamlines the review process. After uploading the articles from the search result, the automatic system in Covidence removed duplicate papers. The remaining articles underwent an initial title/abstract review by at least two reviewers (LH, HW, JM, DD), and then a full text review by two reviewers against specific selection criteria (see Table 1). Any conflicts were discussed and resolved by at least two reviewers in the research team. Two articles were added in the second search. A total number of 263 articles were reviewed and 77 articles were selected for extraction (see Fig. 1 for PRISMA diagram).

Due to a wide array of type and content of the articles, generating selection criteria was challenging. Given the novelty of the topic all nurse specialties were included, except for midwives. While pharmacogenomics may be just as relevant to midwives, this review is focused on the nursing discipline as they have a wider scope of practice in relation to medication administration and interact with people across the entire lifespan. Articles related to other health professions were

Table 1
Selection criteria for scoping review.

Inclusion criteria	Exclusion criteria
Nurse specialties (excluding midwives)	Other health professions than nurses or articles where nurses cannot be separated from other healthcare professions, such as only referred to as "clinicians" or "providers"
	Midwives
Articles presenting at least one paragraph of pharmacogenomics or pharmacogenetics	Articles about genomics which presented with less than one paragraph of pharmacogenomics specifically
Case studies	Book chapters (unless published as articles)
Reviews	
Opinions, perspectives, commentaries, Reports (except news reports)	Teaching material for undergraduate/ postgraduate students
	Letters
Educational papers (papers for continuous professional development)	Dissertations
	Conference abstracts
Articles published after completion of Human Genome Project in April 2003	Articles published before April 2023
Full-text available in English	Full text not available
	Non-human studies
Peer-reviewed articles	Grey literature/not peer-reviewed

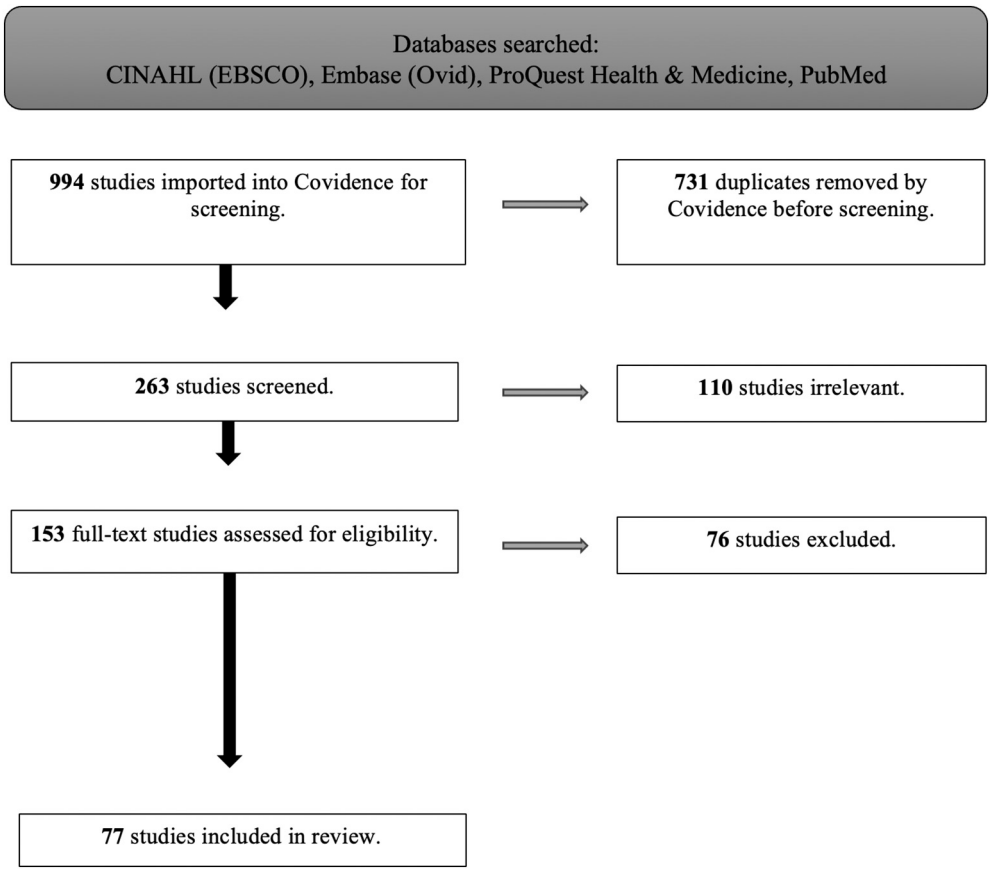

Fig. 1. PRISMA flow diagram from Covidence.

excluded, except for those investigating nurses' use or knowledge of pharmacogenomics as part of the healthcare team. However, if the authors referred only to "clinicians" or "providers" without specifying nurses, the articles were excluded. Articles primarily about genomics were included if they presented at least one paragraph of pharmacogenomics or pharmacogenetics, given the significant interconnection between these topics. Only articles published after the 2003 completion of the Human Genome Project were selected.

The included studies were separated into two categories based on type of data they presented on nurses and pharmacogenomics. The first group is referred to as *empirical research* defined here as articles reporting empirical knowledge such as quantitative or qualitative research conducted by the authors. The second group is referred to as *non-empirical research* consisting of narrative reviews such as literature reviews, perspectives, or commentaries.

3. Findings

A total number of 77 articles met the inclusion criteria. There were 12 articles in the empirical research category (15 %, $n = 12$) and 65 articles (85 %, $n = 65$) in the non-empirical research category. The majority of the empirical research articles used a cross-sectional survey design ($n = 8$), with the remaining methodologies including a pre-post design ($n = 1$), quasi-experimental pre-post (pilot) design ($n = 1$), mixed methods (n = 1), and qualitative open-ended question (n = 1). In the non-empirical research group, there were two literature reviews ($n = 2$). For the sake of this scoping review, a literature review was defined as a review providing a clear methodology and search strategy, in contrast to reviews of literature with no defined search strategy. The majority of the non-empirical articles were considered commentaries or perspectives ($n = 63$) given the absence of a defined research methodology.

The majority of the empirical research were conducted in the United States of America (50 %, n = 6), while Canada, Ghana, Ethiopia, Brazil, Zambia, and United Arab Emirates each presented one article. The non-empirical research articles mainly had author affiliation with the United States of America (86 %, $n = 56$), followed by the United Kingdom (8 %, n = 5), New Zealand (5 %, n = 2), and two articles had author affiliations with more than one country. Seventeen articles ($n = 17$) were published before 2013, after which followed an increase of articles published between 2013 and 2018 ($n = 44$). Between year 2003–2012 only articles with author affiliation to the United States of America, the United Kingdom and New Zealand were published. After 2013, empirical research articles involving nurses and pharmacogenomics were published in USA (n = 6), Canada (n = 1), Ghana (n = 1), Ethiopia (n = 1), Brazil (n = 1), The United Arab Emirates (n = 1) and Zambia (n = 1) (see Fig. 2), however, these articles mainly included nurses as part of the multidisciplinary team ($n = 9$).

The majority of the empirical articles presented limited numbers of nurse participants. The study with the highest participant number included 368 oncology nurses (Dodson, 2014), and this was also the only survey which solely included nurse participants. For the remaining empirical articles, the number of nurse participants ranged from 153 nurses among a total of 552 participants (Rahma et al., 2020), to two nurse practitioners among a total of 53 participants (Johengen et al., 2021). Other health professions frequently included in the survey population were physicians and pharmacists (Abdela et al., 2017; Hayashi and Bousman, 2022; Johengen et al., 2021; Kudzi et al., 2015; Mufwambi et al., 2021; Rahma et al., 2020).

Among the empirical studies, the majority looked at knowledge levels of pharmacogenomics ($n = 5$) (Abdela et al., 2017; Hayashi and Bousman, 2022; Kudzi et al., 2015; Mufwambi et al., 2021; Rahma et al., 2020), attitudes towards pharmacogenomics (n = 4) (Abdela et al., 2017; Dodson, 2015; Mufwambi et al., 2021; Rahma et al., 2020), and

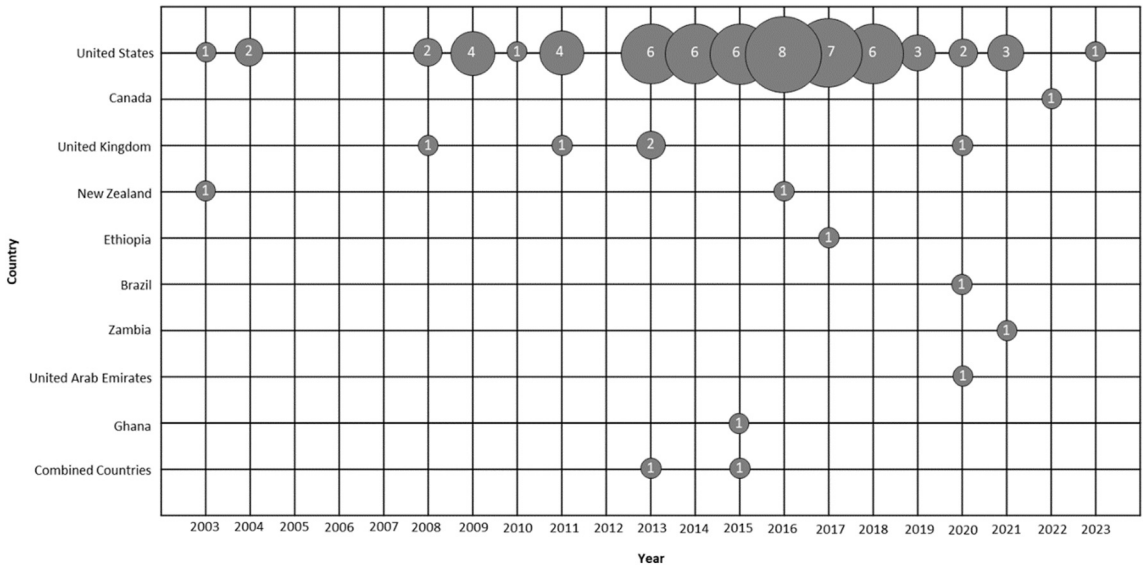

Fig. 2. Bubble plot of articles included in the review by year and author affiliated country. The number inside the bubbles corresponds with the number of articles published that year in the specified country.

two studies looked at pharmacogenomic interest among participants (n = 2) (Abdela et al., 2017; Johengen et al., 2021). The surveys also investigated justification of pharmacogenomics (de Moraes et al., 2020), use and documentation of pharmacogenomics (Johengen et al., 2021), and experiences of use (Hayashi and Bousman, 2022). One survey and the mixed method study looked at experience, perceptions, and perceived utility of pharmacogenomic tests (Hayashi and Bousman, 2022; Riddle et al., 2016). The quasi-experimental pre-post study (Hoffman et al., 2016) and the pre-post design study (Dodson, 2018) investigated educational interventions to increase pharmacogenomics knowledge levels among advanced practitioners and oncology nurses, respectively. The non-empirical articles mainly focused on education of nurses, as well as advocacy for clinical use of pharmacogenomics among nurses in a variety of nursing areas.

Several empirical articles identified a limited knowledge of pharmacogenomics among the participants (n = 8) (Abdela et al., 2017; Dodson, 2014; Dodson, 2018; Hayashi and Bousman, 2022; Hoffman et al., 2016; Kudzi et al., 2015; Mufwambi et al., 2021; Rahma et al., 2020; Riddle et al., 2016), and a need for further pharmacogenomic education (n = 6) (Dodson, 2014; Dodson, 2015; Dodson, 2018; Hayashi and Bousman, 2022; Hoffman et al., 2016; Kudzi et al., 2015). A positive attitude towards pharmacogenomics were noted in some studies (Dodson, 2014; Dodson, 2015; Hayashi and Bousman, 2022; Rahma et al., 2020; Riddle et al., 2016). Barriers to implementation or use of pharmacogenomics were identified as costs (Dodson, 2015; Hayashi and Bousman, 2022; Rahma et al., 2020; Riddle et al., 2016), lack of knowledge and training (Hayashi and Bousman, 2022; Rahma et al., 2020) and limited access to tests (Hoffman et al., 2016; Riddle et al., 2016). One article investigating whether nurses found pharmacogenomics relevant to their profession found only half of the nurse participants reporting it relevant to their practice (Kudzi et al., 2015). Professions identified as best suited to spearhead the implementation of clinical pharmacogenomics were pharmacists, physicians, and genetic counselors (Hayashi and Bousman, 2022).

The content in the non-empirical research articles varied considerably and were mainly focused on educating nurses about various aspects of pharmacogenomics relevant to nursing practice. Four themes were noted to frequently occur: (i) educating nurses on how pharmacogenomics may influence medication safety (70 %), (ii) pharmacogenomics' relevance to nursing practice and justification for nurses' use of pharmacogenomics (64 %), (iii) educating or discussing nurses' role in clinical use of pharmacogenomics and advocate for pharmacogenomic testing of people (59 %), and (iv) educating nurses on how pharmacogenomics can guide selection of certain specified medications (30 %).

The non-empirical articles differed in their focus on pharmacogenomics versus genomics. Of the 65 articles in this category, more than half of authors presented more than one paragraph about pharmacogenomics (n = 36). The remaining articles offered content mainly about genomics but presented at least one paragraph of pharmacogenomics specifically (n = 29). The non-empirical articles were further investigated for whether they contained content or discussions referring to pharmacogenomics as currently in clinical use. Of the non-empirical articles some mentioned that pharmacogenomics was in use or in limited use (n = 14), including in use by other health professionals such as physicians. Few of the articles explicitly mentioned that pharmacogenomics was not in use (n = 6), while the remaining articles did not explicitly discuss whether pharmacogenomics was currently used in a clinical setting (n = 45).

A wide representation of nurse specialties was found among the articles, particularly among the non-empirical research articles. In the non-empirical research category, the largest group was general nurses or nurses with no specified specialty (29 % n = 19). The second and third largest group were nurse practitioners or advanced practices nurses (19 % n = 12) and oncology/palliative care nurses (15 % n = 10) (see Fig. 3).

4. Discussion

This scoping review shows a scarcity of empirical data specific to nurses in relation to pharmacogenomics, with most articles being narrative reviews such as commentaries or perspectives. This aligns with a previous review conducted in 2014 by Knisely et al. (2014), which described a similar shortage of empirical data related to pharmacogenomics in the nursing literature. While there has been a gradual increase in the number of empirical research published since 2014, the current evidence is scarce and cannot be used to guide an evidence-based approach to application of pharmacogenomics into nursing practice. Evidence-based nursing practice relies on high-quality, robust data as well as clinical experience in the local context (Gerrish et al., 2007). There are no clear indicators to why conduct of high-quality research regarding nurses and pharmacogenomics is limited but it should be noted that studies examining pharmacogenomics in connection with physicians and pharmacists are more prevalent. Studies investigating

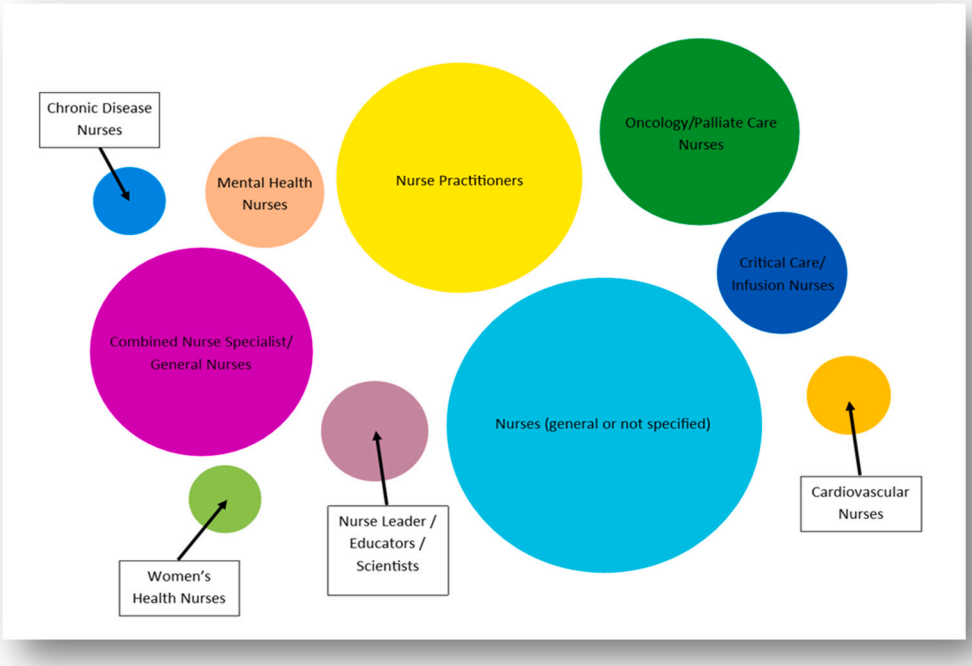

Fig. 3. Bubble chart of nursing specialties included in non-empirical research articles. The size of the bubble corresponds to the prevalence of the nursing specialties.

pharmacogenomics among physicians and pharmacists report a lack of knowledge, time constraints, absence of clear clinical guidelines and ethical considerations as barriers to clinical uptake of pharmacogenomics (Frigon et al., 2019; Lanting et al., 2020). It is reasonable to postulate that some of these barriers would be similarly experienced by nurses, and although the allocation of responsibilities between healthcare practitioners has been reported to be unclear (Lanting et al., 2020) it is likely that physicians and pharmacists will spearhead the uptake of pharmacogenomics into routine healthcare due to their role in prescribing medications (Frigon et al., 2019; Hayashi and Bousman, 2022).

Despite the slow increase in pharmacogenomic research on nurses, there is a growing interest in nurses and genomics. Nurse organisations such as the International Society of Nurses in Genetics (ISONG) and The Global Nursing Alliance (G2NA) are advocating for research and education to advance genomics from evidence into practice as it pertains to nursing practices (Calzone et al., 2018). The American Association of Colleges of Nursing (AACN) are pushing for advances in genomics education for nurses and the Essential Competencies of Genetics and Genomics lists 38 core genomics competencies graduate level nurses are expected to apply in their practice in the US (Hickey et al., 2018). The Australian College of Nursing (2020) published a position statement for nurses in 2020 where they expressed commitment to supporting a workforce ready to apply evidence-based genomic literacy and advance nurse leadership in the emerging genomics era. It is likely that pharmacogenomics is considered integral to these initiatives, as pharmacogenomics is the part of genomics pertinent to medication safety.

Nurses have a significant role in medication administration and patient medication safety and as such it is vital to consider nurses' role and knowledge with pharmacogenomics specifically. With the exception of Dodson (2014), empirical research data included in this review presents nurses only as part of the healthcare team, with some articles including nurses in less than 5 % of the surveyed population. As a result, this data is more representative of other healthcare professions rather than reflecting the knowledge, views, and opinions of nurses. To develop more credible recommendations and directions for the topic, further research focused specifically on the nursing profession is warranted.

In contrast, the non-empirical articles focused on the nursing profession and provided valuable insights from experienced nurse professionals in the field. However, due to their non-empirical nature, they do not add new knowledge to the field. A notable concern of narrative reviews is their lack of transparency regarding the methodologies and search strategies employed. Although such transparency is not obligatory in this type of article, the content is not representative or necessarily an accurate reflection of the current situation. These articles exhibited a wide range of heterogeneity, varying from comprehensive reviews to anecdotal evidence (Aroke and Dungan, 2016; Knisely et al., 2014; Pestka and Shea, 2016) which resulted in varying degrees of content value. While the development of best-practice guidelines for nurses requires a foundation of high-quality evidence, robust "hard" evidence on certain topics is not always readily available (Van Loon and Bal, 2014). Although non-empirical research adds value and debate to the nursing discourse, it cannot serve as a substitute for more rigorous research, and it is due time to move in this direction.

The increasing number of research on nurses and pharmacogenomics accentuates a growing interest and highlights an important shift towards greater involvement of nurses in this field. This is evident particularly in the US, with the majority of articles being published by American authors or authors with an American affiliation. This may reflect the progress the US is making towards acknowledging nurses as important stakeholders in clinical pharmacogenomics. However, and because health systems can vary greatly internationally, the content derived from one country does not necessarily transfer to nurses in other countries. Due to the surge in global pharmacogenomics implementation initiatives (Adesta et al., 2021; Kabbani et al., 2023) and the increasing rationale for clinical use of pharmacogenomics (Swen et al., 2023), non-USA countries are encouraged to conduct further research on pharmacogenomics and nurses in their local healthcare context. This will allow individual countries to generate information that will accommodate the nuances of their own healthcare systems and prepare nurses for pharmacogenomics in the relevant context.

Despite this, an important factor that may translate across borders is the emphasised need for further education on pharmacogenomics. The

strong educational focus identified in this review reflects a perceived need for nurses' increased knowledge and awareness of pharmacogenomics as an emerging new technology with inherent complexities and challenges. The educational needs of health professionals as they pertain to clinical use of pharmacogenomics are known and well documented (Relling and Evans, 2015; Unertl et al., 2015). The focus on pharmacogenomic education for health professionals mirror the authors' shared opinions of the potential for pharmacogenomics to influence and enhance medical therapy practices and improve medication safety and underline the timeliness for this.

Improving pharmacogenomic knowledge among nurses could ultimately lead to nurses' increased involvement with clinical pharmacogenomics in several ways, including discussing pharmacogenomic testing with patients. Patient-oriented research on pharmacogenomics has revealed that patients often struggle to comprehend pharmacogenomic test results and prefer personalised explanations presented in easily understandable language (Olson et al., 2017). This raises the question of whether nurses could step in to address patients' inquiries and/or refer them to the prescribing physician, ensuring that professional boundaries are not exceeded. The discussion surrounding the potential expansion of nurses' roles and responsibilities should be approached with great seriousness. As the healthcare professionals most frequently in contact with patients (Calzone et al., 2018), nurses with sufficient pharmacogenomics knowledge can potentially assist patients' understanding of their pharmacogenomic test results and its relevance to their medical treatment plan (Haga and Mills, 2015; Veilleux et al., 2020), however, further research is required to substantiate this suggestion.

5. Limitations

Due to the heterogeneity of the articles, several decisions were made during the selection criteria process which potentially skewed or limited results. Applying the search term "nurse" but not the term "health professional" in the search may have excluded relevant articles involving nurses. The decision not to include articles which referred to health care professionals only as "clinicians" or "providers" without further specifications may have excluded relevant articles. A total number of 15 abstracts from conferences were excluded, many of which were relevant to the topic. The decision to only include articles if they presented with at least one paragraph of pharmacogenomics may have excluded relevant articles about genomics, because authors frequently used these terms interchangeably. A systematic quality analysis was not performed for any of the articles. Only articles written in English were included which would exclude research on nurses and pharmacogenomics from non-English speaking parts of the world.

6. Conclusion

This scoping review found that the scholarly literature on nurses and pharmacogenomics predominantly exists of narrative reviews and limited empirical data specific to nurses. To facilitate the effective advancement of this topic, the establishment of a more robust evidence base is imperative as the absence of empirical evidence inhibits the development of clear recommendations or guidelines. While we noted a growing number of published articles on the subject in recent years, the focus is on educating nurses rather than offering explicit guidelines to propel the topic forward into nursing practice. The majority of articles were published in the US or by authors with an American affiliation, and nurses from other countries and healthcare contexts are encouraged to engage with and conduct research on the topic. Our review seeks to inspire and motivate nurses to proactively engage with and embrace the evolving landscape of clinical pharmacogenomics as it pertains to their nursing practice and context, across clinical, educational or research areas.

CRediT authorship contribution statement

Linn Helen Hetland: Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Jane Maguire:** Writing – review & editing, Supervision, Project administration, Methodology, Conceptualization. **Deborah Debono:** Writing – review & editing, Supervision, Methodology. **Helen Wright:** Writing – review & editing, Supervision, Methodology.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.nedt.2024.106153.

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