

BMJ Open Genomic literacy in nursing: a systematic scoping review of the literature

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ABSTRACT

Objective To map the available evidence on genomic literacy among clinical nurses, nursing students and nursing faculty.

Design Systematic scoping review.

Data sources A comprehensive search was conducted in PubMed, CINAHL, Scopus, Web of Science, Academic Search Premier and OpenGrey. The review included studies published in English from 1 January 2001 to 28 May 2025.

Eligibility criteria for selecting studies Studies that referenced 'genomic literacy' in health-related or educational contexts and focused on nurses, nursing students or nursing faculty were included. Articles had to provide data on study design, population, setting, data collection tools and outcomes related to genomic literacy.

Data extraction and synthesis Two independent reviewers extracted and summarised data on study characteristics, including publication year, country, setting, aims, methods, population, assessment tools, outcomes and educational interventions. Findings were synthesised descriptively.

Results Of 1534 studies identified, 63 met the inclusion criteria. Most were observational (69.8%) and conducted in the USA (41.3%), focusing on clinical nurses (50.8%) in educational (47.6%) or clinical (46.0%) settings. Genomic literacy was predominantly assessed using ad hoc tools (46.0%) or the Genomic Nursing Concept Inventory, revealing low literacy levels. Mean scores ranged from 5.66 to 16.21 out of 31 (18.3%–52.3% correct answers). Educational interventions demonstrated effectiveness in improving genomic knowledge.

Conclusions Genomic literacy among nurses, students and faculty remains low, with notable heterogeneity across countries. Many studies used non-standardised assessment tools with uncertain reliability and genomic literacy among nursing faculty remains underexplored. Educational interventions show promise in enhancing genomic literacy

BACKGROUND

Genetic research has long been the cornerstone in understanding the hereditary components of diseases.¹ The advent of genomics marked a paradigm shift, encompassing the study of complex interactions among human genes, environmental influences and social

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ This review adheres to the Joanna Briggs Institute scoping review methodology and follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews guidelines, ensuring rigour, reproducibility and transparency.
- ⇒ A comprehensive search strategy was employed, incorporating multiple databases (PubMed, CINAHL, Scopus, Web of Science, Academic Search Premier and OpenGrey) and bidirectional citation searching to maximise the identification of relevant studies.
- ⇒ By including clinical nurses, nursing students and faculty, as well as both primary studies and systematic reviews, this study provides a broad and inclusive perspective on genomic literacy in nursing.
- ⇒ In accordance with scoping review methodology, this study did not assess the risk of bias or methodological rigour of the included studies, which may have influenced the strength of the conclusions.
- ⇒ The heterogeneity of study designs, assessment tools and populations poses challenges for direct comparability and the synthesis of findings across different contexts.

and cultural factors.² The mapping and sequencing of the human genome in 2003, as part of the 'Human Genome Project', revolutionised healthcare services worldwide. It provided insights into the genetic basis of diseases, facilitated their early detection, enabled personalised medicine and drove advancements in research and drug development.³ In this context, integrating genomic knowledge into clinical practice enhances treatment quality and safety, reduces costs and improves healthcare outcomes. It empowers non-specialised healthcare providers to create personalised treatment plans across all phases of care.⁴ Consequently, the role of nurses is increasingly pivotal, as they are actively involved in genomics-based activities such as obtaining family history, assisting patients in making informed decisions about

tests and treatments, making referrals to appropriate healthcare professionals and services, and using genomic information to identify patients at increased risk for certain clinical conditions.⁵

The increasing availability of direct genetic testing, combined with the growing impact of genomics on clinical practice, underscores the need for nurses at all levels to possess specific knowledge and skills for collecting, interpreting and using genomic data to guide patient care pathways.^{4 6 7} In this context, genomic literacy is defined as the capacity to obtain, process, understand and apply genomic information for health-related decision-making.⁸ Figure 1 illustrates the conceptual framework on genomic literacy as a broad construct that encompasses knowledge, competence, confidence and application into practice. The development of genomic literacy begins with knowledge, which enables the acquisition of competence. Competence then fosters confidence, which supports the application of genomics in clinical practice. Importantly, this practical application feeds back into knowledge acquisition through experiential learning and reflection. This framework aligns with Kolb's Experiential Learning Theory, which describes learning as a cyclical process in which concrete experience and reflection lead to the development of new knowledge and competence that can be applied and tested in practice.⁹ This continuous cycle reflects the iterative and evolving nature of genomic literacy and its essential role in supporting evidence-informed, genomics-based patient care.

An expanding body of literature highlights standards and strategies for fostering genomic literacy among nurses.^{3 4} Within this research, education emerges as a priority area of action, recognising nurses as valuable contributors to clinical practice with the potential to facilitate the seamless integration of genomics.^{5 10} Despite efforts to bridge this

gap, the inclusion of genetic and genomic content in formal nursing education remains inconsistent.^{4 5 11} Furthermore, nursing faculty often possess limited knowledge of genomics, which hinders their ability to introduce specialised courses and effectively educate nursing students.^{12 13} Additionally, there is evidence that most nurses have not received genomic education since licensure.¹¹ Nurses' genomic knowledge has been reported as low, with many expressing a lack of confidence in applying this knowledge in clinical practice.¹¹ The majority of available studies tend to focus exclusively on either educational setting⁶ or clinical contexts,^{14 15} resulting in a fragmented understanding of genomic literacy within the nursing profession as a whole. These gaps prevent nurses from assuming key roles in promoting the integration of genomics into healthcare, as insufficient knowledge and confidence hinder their ability to advocate for genomic applications, educate patients, interpret test results and collaborate effectively with interdisciplinary teams. To address these shortcomings and enable nurses to contribute effectively to genomics-based care, it is essential to implement targeted educational initiatives that accommodate the specific learning needs and literacy levels of different nursing groups.⁶ However, in line with the principles outlined in the Global Genomics Nursing Alliance (G2NA) Roadmap for accelerating the global integration of genomics into nursing, designing and implementing such educational interventions require a clear understanding of the current baseline of genomic literacy.^{4 10} While a recent scoping review¹⁶ charted the progress of genomics in nursing and midwifery over the past decade, focusing on provider-oriented outcomes associated with the integration of omics principles into clinical practice, it did not specifically examine genomic literacy outcomes across diverse nursing populations, nor did it systematically evaluate the effectiveness of educational interventions. Our review aims to fill this important gap by offering a broader, outcome-oriented synthesis focused on literacy levels, competencies and educational strategies. Mapping the literature by considering concepts, time frames, locations and sources remains essential to inform current nursing practice and education, while simultaneously guiding future research efforts.

Aims and review questions

This study aims to systematically map the existing literature on genomic literacy among nursing faculty, professionals and students, as well as to identify evidence gaps related to this topic.

Based on the available literature, this systematic scoping review addresses the following research questions: (1) What is the extent of the evidence regarding genomic literacy among nursing students and professionals in educational and clinical care settings? (2)

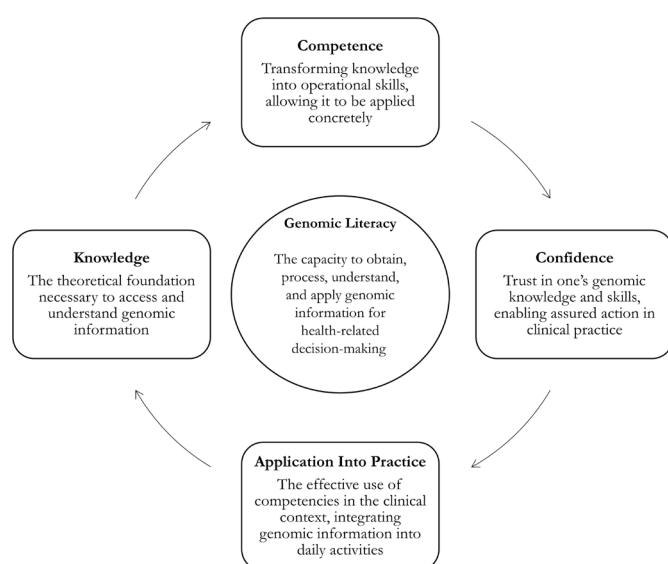


Figure 1 Cyclical framework of genomic literacy.

What are the evidence gaps regarding genomic literacy in the context of nursing education and practice?

METHODS

Study design

A systematic scoping review was conducted following the Joanna Briggs Institute (JBI) methodology for scoping reviews.¹⁷ Given the extensive nature of the topic, a scoping review methodological approach was considered the most suitable, particularly for its ability to provide an overview of the literature on a specific subject.¹⁸ The research report adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist.¹⁹

Eligibility criteria

The PCC (Population/Concept/Context) mnemonic was used to delineate the eligibility criteria.¹⁷ Primary studies and systematic reviews were included if they met the following criteria: (a) the target population consisted of nurses, nursing students and/or nursing faculty (P); (b) the studies addressed the concept of 'genomic literacy', defined as 'the capacity to obtain, process, understand and use genomic information for health-related decision-making'⁸ (C), and (c) the studies were conducted in any healthcare sector or nursing professional education setting, regardless of the country (C). Studies including mixed samples (eg, nurses and other professionals) and providing only aggregated data were excluded. To minimise the potential loss of relevant manuscripts, studies addressing genomic knowledge and/or genomic competence were also considered for inclusion, as these concepts are closely related to genomic literacy. Articles written in languages other than English were excluded, as were those that did not include a qualitative or quantitative assessment of genomic literacy. While systematic reviews were eligible for inclusion, all other forms of literature reviews were excluded.

Search strategy

The electronic search strategy aimed to identify both published and unpublished studies. An initial PubMed search was conducted to retrieve relevant articles and related keywords and MeSH terms related to the topic. These were employed to develop a comprehensive search strategy for electronic databases, including PubMed, CINAHL, Scopus, Web of Science (WOS), Academic Search Premiere and OpenGrey. The search strategy was tailored for each individual database, combining the selected key words with Boolean operators (AND, OR). The complete search strings are reported in online supplemental file S1. No date range was applied as a limit; however, articles in languages other than English were excluded. The initial search was conducted on 22 July 2022, followed by an updated search on 15 November 2023. A second update was performed on 28 May 2025, during the manuscript revision process. To increase the

number of potentially relevant studies, a bidirectional citation search of the included papers was conducted on Scopus.²⁰

Study selection and data extraction

The screening of titles and abstracts, along with the examination of full texts and data extraction, was independently conducted by two researchers. Any discrepancies were resolved through discussion with an additional reviewer. Potentially relevant sources were retrieved in full text through the University Library System, with support from university librarians, and by directly contacting the authors.

References were collected and managed using EndNote 21.5 software.

Data were extracted using a Microsoft Excel data extraction worksheet previously developed and tested by researchers. Extracted information included first author, publication year, country, setting, aims, study design, population, number of participants, data collection tools, outcomes and main findings. If included, details on educational interventions were also extracted and organised within the framework provided by the Guideline for Reporting Evidence-based practice Educational interventions and Teaching (GREET) specifically written to provide a consistent and transparent reporting for evidence-based educational interventions.²¹

In this context, the following data were extracted: aim/s, description, underlying theory, learning objective, evidence-based practice content, materials, educational strategies, incentives, instructors, delivery method, environment, schedule, planned/unplanned changes, attendance facilitation, participation rate, compliance with planned material and educational strategies, and compliance with schedule.

Data synthesis and quality appraisal

Data were presented in tabular form or graphically through bubble plots, pie charts and bar charts. Additionally, a narrative summary was provided.

With regard to outcomes, only those strictly related to the concept of genomic literacy were considered. In this context, outcomes were organised into five main dimensions: (1) genomic literacy, (2) knowledge (either directly measured or self-reported), (3) competency (using knowledge in practice, being able to perform tasks), (4) application in practice (performing genetic/genomic-related activities) and (5) confidence (self-reported confidence in knowledge or in performing actions, clinical comfort). According to the JBI methodology, no quantitative analysis of results was performed in this scoping review.¹⁷ While such an analysis was not required, it was also not feasible due to the heterogeneity of outcome measures. To provide a meaningful comparison and summary of the retrieved evidence, comparable elements were extracted from the included studies, relying on the original authors' assessments of their outcomes (eg, high, low, moderate or gain/loss) to ensure consistency across studies. The

sources of evidence included in this scoping review were not assessed for the risk of bias or methodological quality, following current recommendations.^{17 18}

Ethical consideration and protocol

As this study does not involve participant enrolment, ethical approval was not required. The review protocol has been published.²²

RESULTS

The database searches identified 920 papers. Supplementary research strategies allowed to retrieve an additional 614 studies, bringing the total to 1534 articles. After removing duplicates (n=434) and screening of titles and abstracts, 92 articles were deemed eligible and obtained in full. Following a full-text review, 29 papers were excluded based on predefined inclusion and exclusion criteria. In total, 63 papers met the inclusion criteria and were included in this scoping review.^{6 12–15 23–80} The initial search and the first update are presented in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram (figure 2), while the results of the most recent update, conducted on 28 May 2025, are reported in the online supplemental files (S2 – PRISMA flow diagram).

Characteristics of the included studies

The main characteristics of the included studies are summarised in online supplemental file S3. The papers

were published between 2001 and 2025. Remarkably, half of these studies were conducted after 2018, indicating a notable increase in publications in recent years (figure 3a). Geographically, most of the studies originated from the USA (n=26, 41.3%),^{12 13 26–28 31–35 38 44 51 52 56 57 62 64–68 75 76 78 79} though contributions from various other countries are also represented, as shown in figure 3b.

Of the included studies, 29 (46.0%) explored multiple objectives,^{6 12 15 23–25 27 28 30 31 35 36 39 40 42 43 50 56 58 59 61 65 67 73 75 77–80} typically focusing on assessing genomic literacy in

relation to other outcomes, such as educational needs or the integration of genomics into practice, education and research. A notable proportion of studies (n=14; 22.2%) exclusively explored genomic literacy, genetic knowledge or genomic competency.^{13 14 33 37 48 49 53–55 63 70–72 74} Similarly, another 20.6% (n=13) focused exclusively on investigating the effectiveness of teaching strategies to enhance genomic literacy.^{26 29 34 38 44–47 51 52 62 68 76} Detailed information about study aims is provided in online supplemental file S4.

In terms of study populations, 50.8% of the articles (n=32) focused on clinical nurses,^{5 14 15 24 25 27–29 31 36 38 40–42 45 46 49 54 56 58–61 63 69–74 77 78}

encompassing a total of 18 157 participants (range=6–8150). Another 31.7% of the studies (n=20) examined students,^{6 23 32 34 39 43 47 48 50 51 53 55 62 64–68 75 79} with a total of 5499 participants (range=27–1002).

Additionally, 4.7% of the articles (n=3) targeted faculty members,^{12 13 76} involving 538 participants (range=13–495). The remaining 12.7%

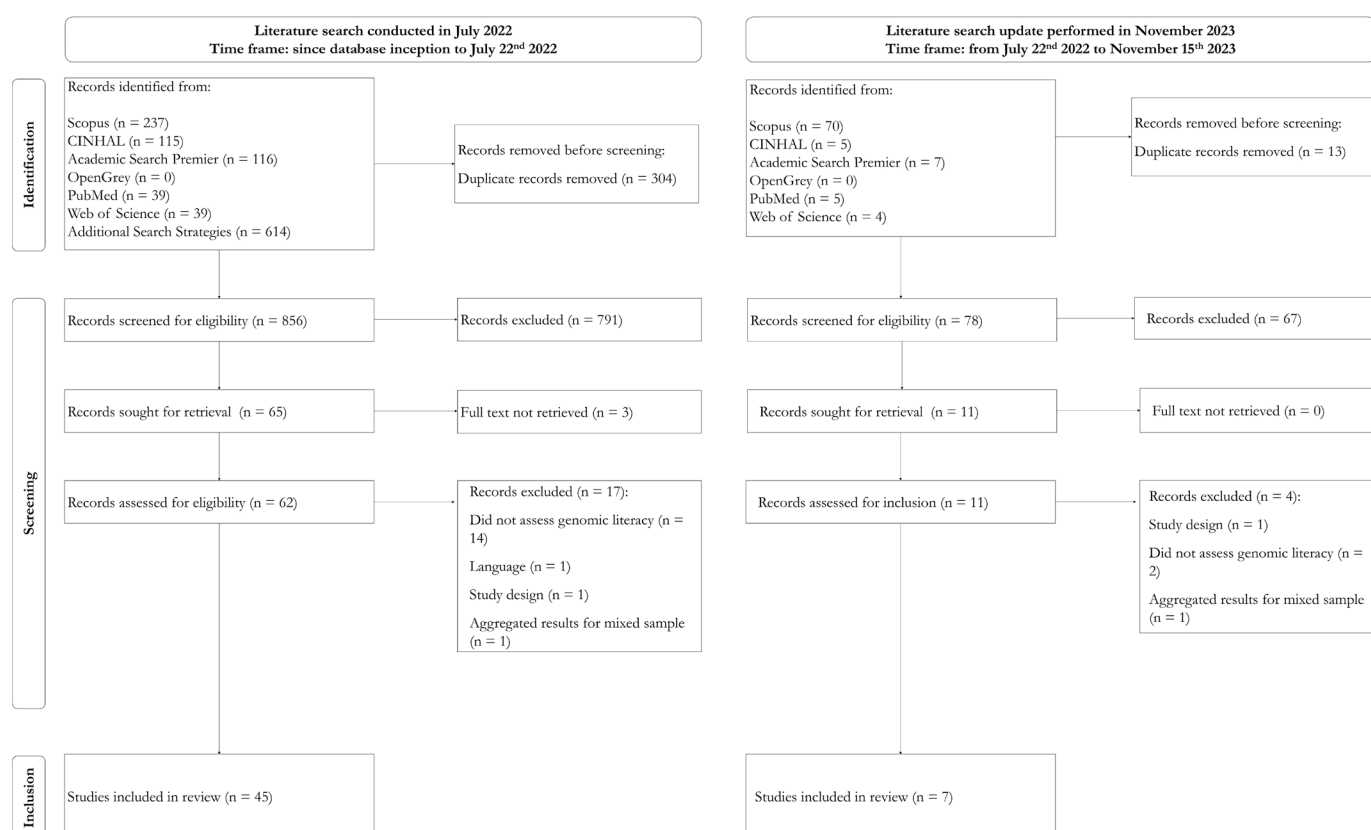


Figure 2 Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram.

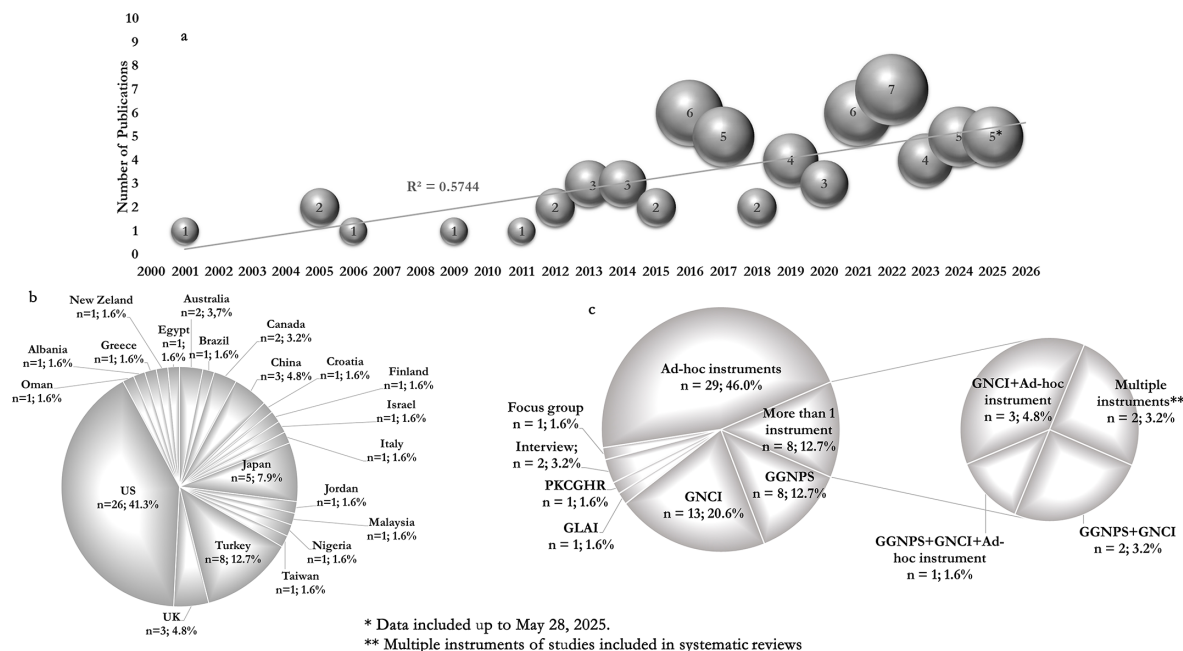


Figure 3 Bubble plot and pie charts about publication timing, geographical distribution of studies, and data collection tools. (a) Time distribution of the included study. (b) Geographical distribution of included studies. (c) Data collection tools used in included studies.

of the studies (n=8) included diverse participant groups, such as combinations of faculty and students^{33 35 37 52 57} or students and clinical nurses,^{30 80} and one on nurse leaders.⁴⁴

Participants were predominantly enrolled in educational settings (n=30; 47.6%)^{6 12 13 23 27 32–35 37 39 43 47 48 50–53 55 57 62 64–68 75 76 79 80} or clinical settings (n=29; 46.0%),^{14 15 24–26 29 31 36 38 40–42 44–46 49 54 56 58 59 61 63 69 70 72–74 77 78} with most studies employing an observational design (n=44; 69.8%)^{6 12–15 23 25 27 30–33 35–40 42–44 47–50 53–56 58 61 63 65–67 70–74 77–80} or a before-and-after

study design (n=9; 14.3%).^{26 29 34 45 51 52 62 68 76} Comprehensive details on population characteristics, study settings and design methodologies are provided in online supplemental file S5.

Most data collection tools used in the included studies were ad hoc instruments (n=29; 46.0%)^{12 23–25 31 34 36 42 43 45–51 56 58 59 61 62 68 72–77 80} specifically developed to meet the unique objectives of each study. Additional data collection methods included interviews^{64 69} and focus groups.⁴¹ Among the validated quantitative tools, the most frequently used was the ‘Genomics in Nursing Concept Inventory’ (n=19; 30.2%),^{6 13 14 30 33 37–40 52 53 55 57 65–67 70 78 79} as shown in figure 3c.

Educational interventions

14 studies (22.2%) investigated the effectiveness of educational interventions^{5 29 34 38 44–47 51 52 62 68 76 80} which exhibited considerable heterogeneity in their reporting according to the GREET guidelines (online supplemental file S6a, b). The target populations included clinical nurses (n=5),^{26 29 38 45 46} nursing students (n=5),^{34 47 51 62 68} nurse leaders (n=1),⁴⁴ faculty members (n=1)⁷⁶ and mixed populations (n=2).^{52 80} The most frequently employed study

design to assess the effectiveness of these interventions was the before-and-after design (n=9).^{26 29 34 45 51 52 62 68 76}

Intervention delivery was predominantly online (n=9)^{26 29 34 38 44 47 52 68 76} either fully or with an online component, with case studies and lectures being the most used educational strategies. The educational content varied across studies; however, some interventions (n=6)^{34 44 51 52 68 76} incorporated content based on recognised core competencies.^{2 81 82} Notably, only four articles provided details about the instructors,^{29 51 68 76} and only one reported information about the physical or virtual spaces where the interventions were conducted.²⁹ Furthermore, no studies included steps related to evidence-based practice in the design or implementation of the interventions. Finally, there was no indication of how authors evaluated whether the interventions adhered to the original plans regarding materials, educational strategies and schedules.

Investigated outcomes and findings

Majority of the studies (n=33; 52.4%)^{5 12 15 23 27–29 31–34 36 38 41 43 45–48 50 52 54 58 60 63 68 71 73–77 80} investigated two or more categories of outcomes, while others (n=30; 47.6%)^{6 13 14 24 25 30 35 37 39 40 42 44 49 51 53 55–57 59 61 62 64–67 69 70 72 78 79} focused exclusively on a single category of outcomes, such as genomic literacy, knowledge, competency, application in practice, or confidence. Knowledge was the most frequently investigated outcome category, followed by confidence. Competency was addressed in only a minority of the studies (online supplemental file S3).

Genomic literacy

Genomic literacy levels were consistently assessed using the Genomic Nursing Concept Inventory (GNCI) across

16 studies.^{6 13 14 30 33 37 39 40 53 55 65–67 70 78 79} These included four studies focusing on clinical nurses,^{14 40 70 78} only one on a mixed sample of clinical nurses and students,³⁰ two on a mixed sample of students and faculty,^{33 37} one on faculty alone¹³ and eight on students.^{6 39 53 55 65–67 79} Reported mean scores ranged from 5.66 (SD=3.22; 18.3% correct answers)¹⁴ to 16.21 (SD=3.58; 52.3% correct answers)⁵⁵ out of a possible 31. In one study,³³ students achieved a median of 54.8% correct answers, while faculty reported a median of 48.4%.

Knowledge in genetics and genomics

Seven studies on clinical nurses reported knowledge levels ranging from moderate to good (11.1%),^{24 42 49 59 63 71 72} while two studies revealed low to moderate levels instead.^{25 74} Additionally, a cohort of students and faculty assessed with the Genetic Literacy Assessment Instrument (GLAI) achieved mean percentages of correct responses of 73% and 76%, respectively.³⁵ A comparable result (73.3%) was observed in a sample of nurses using an ad hoc survey on congenital anomalies.⁷³ In two additional studies, clinical nurses scored a mean of 6.47 out of 11 (SD=2.02) using an ad hoc instrument,⁵⁸ while students achieved a mean score of 19.28 out of 37 (SD=4.35) on the Perceived Knowledge and Competency of Family History Risk Assessment Questionnaire (PKCGHR).³² Conversely, 17 studies (27.0%) reported low levels of knowledge.^{12 15 23 27 28 31 36 38 41 43 44 54 56 57 61 64 77} Of these, 11 focused on clinical nurses,^{15 27 28 31 36 38 41 54 56 61 77} 3 on students,^{23 43 64} 1 on a mixed sample of students and faculty,⁵⁷ 1 on faculty alone¹² and 1 on nurse leaders.⁴⁴ Additionally, two studies identified knowledge gaps among students.^{48 75} In three studies, clinical nurses self-reported low levels of knowledge; however, their scores were moderate when evaluated using the knowledge dimension of the Genetics and Genomics in Nursing Practice Survey (GGNPS), with mean scores of 8.30 out of 12,¹⁵ 8.99 out of 12²⁷ and 8.59 out of 12.⁵⁴ Similarly, other researchers reported that 58% of students perceived their knowledge as inadequate.⁵⁰ However, when assessed, their identification of basic knowledge concepts ranged from 31.5% to 93.2%, while knowledge of diseases ranged from 8.1% to 60.8%.⁵⁰ In another study involving a mixed sample of clinical nurses and nursing students, knowledge levels were found to vary significantly.⁸⁰ The systematic review found insufficient evidence to assess the level of clinical nurses' knowledge.⁶⁰

Competency

Low levels of competency among clinical nurses were reported in four studies.^{27 63 71 74} Fair and poor levels of competency were also observed in a study involving students and faculty.³³ When self-perceived competency was assessed in students using the PKCGHR, the mean score was 3.62 out of 5 (SD=0.63).³² In other studies, 58.1% of students reported feeling competent in collecting family histories; however, 69.4% indicated they did not feel competent in constructing a pedigree.⁵⁰ Regarding

the systematic review, authors did not find sufficient evidence to evaluate the competency of clinical nurses.⁶⁰

Application of genomic knowledge into practice

Three studies quantified the percentage of clinical nurses collecting patient family histories, reporting rates of 43.2%,⁶³ 62%⁷⁷ and 72%.³¹ However, one study found that 62.9% of nurses rarely or never collected family history.⁵⁴ Overall, 8 out of 12 studies examining this outcome highlighted low levels of actual application of genomic knowledge in practice. Of these, seven focused on clinical nurses^{15 27 28 36 41 71 73} and one on students.²³ Additionally, in another study, both students and faculty reported feeling unprepared to apply genomic knowledge in practice.³³ Regarding clinical nurses, a study conducted in Australia revealed that nurses were applying genomic knowledge into practice at a reduced capacity.⁶⁹

Confidence in knowledge or in performing actions, clinical comfort

Most studies (n=6) reported low levels of confidence among participants regarding their genomic knowledge or ability to perform genomic-based activities.^{12 27 36 43 75 80} Among these, two focused on clinical nurses,^{27 36} two on students,^{43 75} one on faculty¹² and one on a mixed sample of clinical nurses and students.⁸⁰ Instead, two other studies reported variable levels of confidence.^{28 54} Similarly, another study on students reported variable levels of confidence.⁴⁸ Conversely, two studies on clinical nurses documented high levels of confidence.^{63 71} Additionally, one study found that 60.6%–74.4% of clinical nurses felt confident in adopting and integrating genomics into practice,¹⁵ while another study reported that clinical nurses expressed confidence in their genomic knowledge.⁵⁸ The systematic review on clinical nurses concluded that there was not enough evidence on this outcome.⁶⁰

Educational interventions

When reported, all educational interventions demonstrated improvements in at least one of the investigated outcomes. Specifically, knowledge improved in every study assessed (n=9).^{26 29 34 45–47 62 68 76} Of these, four targeted students,^{34 47 62 68} four focused on clinical nurses^{26 29 45 46} and one involved faculty.⁷⁶ Regarding other outcomes, increases in confidence were observed in six of the eight studies that examined this aspect. Among these, two included students,^{47 68} one focused on faculty⁷⁶ and three focused on clinical nurses.^{29 45 46} The two studies that did not report gains in confidence involved students³⁴ and clinical nurses.²⁶

Three studies investigated practice-related outcomes: two reported minimal improvement among clinical nurses,^{26 29} while the other showed no gains for students.³⁴ Competency was examined in four studies, with three reporting improvements among nursing students, doctoral nurses and doctoral nursing students, and clinical nurses.^{29 51 52} Clinical nurses from another study showed no improvement in this outcome.²⁶ Finally, two studies that assessed genetic literacy as an outcome

reported improved literacy among clinical nurses and a mixed sample of doctoral nurses and doctoral nursing students following the intervention.^{38 52}

DISCUSSION

Characteristics of included studies

The time distribution of the included studies highlights a growing interest in genomic literacy in recent years. This reflects how new knowledge about the human genome, driven by significant technological advancements, has been gradually integrated into clinical practice,¹ thereby necessitating specific knowledge and skills from nurses.^{5 6} Consequently, nursing researchers are increasingly focusing their attention on this topic, supported by the efforts of international associations like the G2NA, which aim to facilitate the integration of these advancements into nursing practice.¹⁰

At the forefront of this research field is the USA (just over 40.0%). This geographic concentration should be taken into account when considering the generalisability of findings across diverse healthcare systems and educational contexts. While some European countries have contributed to the literature, they remain under-represented^{6 24 39 40 42 55 60} and studies from low- and middle-income countries are particularly scarce. Notably, recent research has highlighted substantial regional disparities in genomic literacy. For example, Parviainen *et al*⁵⁵ reported significantly lower literacy scores among Finnish nursing students compared with their Filipino counterparts, and Alloubani *et al*¹⁴ documented alarmingly low levels among nurses in Jordan. These findings underscore the influence of local context, access to genomic education, and national healthcare infrastructures in shaping literacy outcomes. To promote equitable progress in genomic nursing education and practice, further regionally tailored studies and interventions are urgently needed.

Regarding the investigated population, merely three studies focused on faculty^{33 57 76} and only one aimed at enhancing the ability of nursing faculty to teach genetics and genomics.⁷⁶ However, given the low level of genomic literacy among faculty and their crucial role in transmitting knowledge, it is imperative to prioritise investment in their education. This would facilitate the creation of a virtuous cycle wherein the learning trajectory of students enhances its consistency, as advancements in practice generated by genomics would already be integrated into theoretical teachings. Most of the educational interventions documented in this review were conducted in online environments, not directly related to clinical practice. To bridge the gap between theory and practice and facilitate the anticipated integration of genomics into nursing clinical practice, these educational models should be complemented with activities specifically tied to clinical practice.

Concerning the research designs employed in the included studies, the results highlight the need for study designs that provide higher levels of evidence, such as

randomised controlled trials, especially for those aimed at investigating the effectiveness of educational interventions in promoting genomic literacy. In fact, most of the studies were observational in design, and those encompassing an educational intervention were designed with a before-and-after approach.^{26 29 34 45–47 51 52 62 68} Furthermore, when investigating genomic literacy, the use of validated evaluation tools should be prioritised over ad hoc instruments. Indeed, nearly half of authors used ad hoc instruments in their studies.^{12 23–25 31 34 36 42 43 45–51 56 58 59 61 62 68 72–77 80}

Although this could be expected, given the recent and rapid development of genomic nursing, this poses challenges for comparing results, obtaining a clear picture of available evidence and establishing valid, reliable and generalisable measures of the phenomenon. In this context, using ad hoc instruments could entail the risk of not accurately or comprehensively measuring the phenomenon of interest, whereas validated tools are designed to mitigate this risk. Furthermore, ad hoc tools may exacerbate the risk of fragmenting the broad concept of genomic literacy into its various dimensions.

Outcomes and educational interventions

The findings from the included studies reveal a widespread low level of genomic literacy among clinical nurses, students and faculty. This result was also observed in other outcomes encompassed within the definition of genomic literacy, including knowledge, competency, application in practice and confidence. To address these gaps, educational interventions have been implemented to enhance knowledge.^{26 29 34 45–47 62 68 76} While these interventions have demonstrated effectiveness in improving knowledge, their impact on fostering professional practice and competencies has been limited, with minimal or no observable improvements.^{26 29 34 51} It is crucial to interpret these results in the context of the heterogeneity observed among educational interventions, which vary in aims, content, materials and methodologies. To establish a robust baseline of knowledge necessary for sustaining nursing activities, it would be beneficial to prioritise the standardisation of educational interventions with clear objectives and consistent contents. Additionally, strengthening the reporting of these interventions using tools such as the GREET guidelines would enhance reproducibility and comparability.²¹ Simultaneously, interventions should aim to support the development of genomic-based competencies and encourage their practical application. This approach would empower clinical nurses in their roles and enable students to enter work environments that foster professional growth and competency development. It is also important to interpret these findings in light of the relative novelty of genomic literacy as a formal component of nursing education and practice. As an emerging discipline, most educational efforts have understandably focused on foundational knowledge rather than advanced competencies or clinical application. This pattern aligns with established educational evaluation models, such as Kirkpatrick's framework,⁸³ which

emphasises that early educational research often concentrates on learner satisfaction and knowledge acquisition before advancing to behavioural and outcome-level evaluations. Furthermore, the current clinical and academic context may not yet be mature enough to support fully integrated genomic practice, as even faculty and clinical nurses often demonstrate limited genomic literacy themselves.^{30 33 40 57} These contextual factors help explain why few studies have addressed the translation of genomic knowledge into practice, suggesting that the observed limitations may stem not only from study design but also from the broader developmental stage of the field itself.

In this evolving context, the limited effects observed on competency and practice may also be attributed to structural weaknesses in the interventions themselves, many of which are short-term, not embedded into clinical workflows, or lack follow-up strategies to support sustained skill development and practical integration. This is consistent with findings by Alloubani *et al*,¹⁴ who emphasised the importance of implementing longitudinal educational strategies, incorporating genomic literacy into nursing curricula and adopting evidence-based formats such as workshops, case studies and simulations to ensure long-term retention and application of genomic knowledge in clinical practice.

Strengths and limitations

To the authors' knowledge, this is the first literature review to systematically map evidence on genomic literacy in the nursing field, comprehensively encompassing clinical nurses, nursing faculty and students. A key strength of this work is its adherence to established methodologies, such as the JBI framework and PRISMA-ScR guidelines, ensuring a systematic and transparent approach to conducting and reporting the review.^{17 19} Additionally, the identification of critical evidence gaps, such as the under-representation of nursing faculty and the limited number of studies from regions outside the USA, provides valuable insights to guide future research and practice. Another strength is the detailed analysis of educational interventions using the GREET framework.²¹

This evaluation underscores the need for standardised educational models that integrate genomic literacy into clinical practice, a crucial step in bridging the gap between theory and application. The inclusion of studies addressing diverse outcomes, such as knowledge, competency and confidence, offers a nuanced understanding of the current state of genomic literacy in nursing. However, the review also has limitations. The predominance of US-based studies limits the generalisability of findings to regions with different healthcare systems and educational structures. Furthermore, the heterogeneity in study designs, outcomes and methodologies complicates the synthesis and comparison of results. As observed in several of the included studies, a notable issue is the frequent use of ad hoc instruments to measure genomic literacy, which raises concerns about the reliability and comparability of findings. These tools,

often developed for specific research purposes, may fail to adequately capture the multidimensional nature of the concept and may introduce variability in outcome measurement. This makes cross-study comparisons difficult and reduces overall confidence in the conclusions. For this reason, future research should prioritise the use or development of validated and psychometrically sound instruments that can be consistently applied across settings and populations. However, given the rapid advancements in the genomic field, even validated tools require continuous monitoring and periodic updating to ensure they reflect current knowledge and clinical relevance. Without such attention, there is a risk of premature obsolescence of assessment instruments, which could compromise their utility in both research and educational evaluation.

As the review did not evaluate the methodological quality of the included studies, the results should be interpreted cautiously, considering the potential inclusion of studies with varying levels of rigour and reliability. By addressing these challenges, the nursing profession can better integrate genomics into practice, ensuring genomic literacy becomes a foundational element of nursing education and clinical care.

In line with JBI guidance, a formal risk of bias assessment was not conducted. However, some potential sources of bias across the included studies should be acknowledged. These include the widespread reliance on self-reported data, the absence of control groups in some intervention studies and variability in measurement strategies. Collectively, these limitations may affect the robustness of the conclusions and should be considered when interpreting the results. Recognising these issues is essential to guide the design of more rigorous and comparable studies moving forward. To strengthen future research, greater emphasis should be placed on the use of validated and psychometrically robust instruments. Moreover, given the rapid and ongoing evolution of the genomic field, validated tools require continuous monitoring and periodic updating to ensure they reflect current knowledge, competencies and clinical practices. Without such revisions, assessment instruments risk becoming outdated, thus compromising their relevance for both research and educational evaluation. By addressing these methodological challenges, the nursing profession can better integrate genomics into practice, ensuring that genomic literacy becomes a foundational element of nursing education and care across diverse contexts.

This review included only studies published in English, which may have led to the exclusion of relevant research published in other languages. Although this choice was based on practical constraints, it may have limited the completeness of the evidence base by overlooking contributions from certain countries. However, as English is widely used for scholarly communication worldwide, including in non-English-speaking countries, the findings remain broadly applicable and informative for international nursing education and practice.

Clinical relevance

Although evidence is limited and heterogeneous, nurses, students and faculty reported alarmingly low levels of genomic literacy and its associated outcomes such as knowledge, competency, practical application and confidence. Educational interventions have demonstrated their effectiveness in improving knowledge across all populations, but gains in confidence and competency have been less consistent, particularly among clinical nurses. Furthermore, despite some improvements, the practical application of genomic knowledge in clinical settings remains notably limited, revealing a critical gap in translating genomic literacy into actionable practice. These findings underscore the need for robust, tailored educational strategies to address these deficits and ensure that genomic advancements are effectively integrated into nursing practice.

To move the field forward, several concrete actions are needed. These recommendations are grounded in the GenoNurse Educational Model and RoadMap, a recently published framework designed to support genomic education in nursing.⁸⁴ First, genomic content should be systematically embedded within undergraduate and postgraduate nursing curricula, ensuring that all nurses acquire essential genomic knowledge and competencies early in their professional development.

Second, continuing education programmes should be promoted within clinical settings, ideally through mandatory training modules that are practice-oriented and aligned with institutional priorities. Third, education should be coupled with organisational support to enable nurses to apply genomic knowledge in daily care through clinical decision tools, interdisciplinary collaboration and access to genetics experts.

Finally, the use of structured models such as the GenoNurse Educational Model and RoadMap can guide the design, delivery and evaluation of genomic education across academic and healthcare settings, fostering a more consistent and integrated approach to competency development. These efforts are in line with international calls to action, such as those outlined by the G2NA, which advocates for the systematic integration of genomics into nursing education, practice and policy to ensure global workforce readiness.^{5 10}

CONCLUSION

This review underscores a growing interest in genomic literacy, driven by technological advancements and an evolving understanding of the human genome. However, the analysis of included studies revealed several gaps. Notably, many countries have yet to engage in research on this topic. Additionally, genomic literacy among nursing faculty remains significantly underexplored. Another limitation is the low level of evidence available, particularly regarding the effectiveness of educational interventions designed to promote genomic literacy. The

over-reliance on ad hoc measurement tools further exacerbates this issue.

The findings from the included studies indicate low levels of genomic literacy among clinical nurses, students and faculty. This deficiency extends to key aspects of genomic literacy, including knowledge, competency, application in practice and confidence. Despite the observed heterogeneity, educational interventions have proven effective in enhancing knowledge; however, their impact on competency and professional practice remains limited.

Future research should address these gaps to develop a comprehensive global understanding of genomic literacy and its implementation in nursing practice. Efforts should prioritise engaging under-represented countries in genomic literacy research to foster broader participation. Furthermore, as faculty play a crucial role in disseminating genomic knowledge, additional studies are needed to investigate their literacy levels. Investing in faculty education is essential to align students' learning trajectories with genomic advancements and better prepare them for future nursing practice.

To enhance the quality of evidence, future research should employ more rigorous study designs, such as experimental approaches where appropriate, and prioritise the use of validated assessment tools to ensure reliability and comparability of findings. Additionally, standardising the content of educational interventions will help establish a baseline of genomic knowledge necessary for nursing education. Finally, efforts should focus on developing strategies to enhance nurses' capacity to deliver genomic-based care, ensuring genomic literacy becomes an integral component of nursing education and clinical practice.

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