Appendix A: Supplementary data

*Table 2. Characteristics of included studies*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Author/Year | Country | Method  | Population | Topic |
| **Study type 1.** **Measuring nursing student and or faculty genomics knowledge, or post-intervention genomics knowledge gains** |
| Adejumo et al., 2021 | Nigeria | Mixed methods | Nursing students (n=136) | Measuring knowledge related to genomic concepts using a tool and surveying readiness for practice |
| Anderson et al., 2015 | US | Literature Review |  | Evaluation of survey instruments that assess knowledge, skills, and attitudes of genomic nursing |
| Bashore et al., 2018  | US | Quantitative | Faculty (n=29) | Pre- and post-intervention testing using a tool to measure learning gains |
| Dewell et al., 2020  | Canada | Quantitative | Nursing student and faculty (n=298) | Measuring knowledge and understanding of genomic concepts using a tool |
| Donnelly et al., 2017 | US | Quantitative | Faculty (n=20) | Surveying genomics knowledge and confidence and identifying needs to inform development |
| Hsaio et al., 2011 | Taiwan | Quantitative | Nursing students (n=434) | Exploring perceived knowledge and comfort with genomics |
| Jaekel, 2012 | US | Quantitative | Nursing students (n=114) | Dissertation including a study measuring learning gains following an online module |
| Jenkins & Calzone, 2014 | US | Qualitative  | Faculty (n=19) | Determining whether faculty champions influenced genomics integration and evaluating knowledge |
| Kawasaki et al., 2021 | Japan | Quantitative | Nursing students (n=46) (and n=56) | Self-rating of knowledge following traditional face to face genomics teaching compared to knowledge gained from remote teaching during the Covid-19 pandemic |
| Kronk et al., 2018 | US | Mixed methods | Nursing students | Measuring knowledge gains following a new genomics course and assessing perceptions about value of the content and knowledge attainment  |
| Majstorović et al 2021 | Croatia | Quantitative | Nursing students (n=53) | Determining the extent of genomics content in nursing programmes (n=10) and measuring understanding of genomic concepts using a tool |
| Mathis, 2022 | US | Qualitative  | Faculty (n=23) | Exploring perceived changes in knowledge and confidence following an educational programme |
| Munroe & Loerzel, 2016 | US | Mixed methods | Nursing students (n=109) | Measuring knowledge gains and assessing attitudes and readiness to practice |
| Parviainen et al., 2023 | Finland & The Philippines | Quantitative | Nursing students (n=245) | Investigating genomic literacy |
| Read & Ward, 2016 | US | Quantitative | Faculty (n=495) | Evaluating understanding of foundational genomic concepts using a tool  |
| Read & Ward, 2018 | US | Quantitative | Nursing students (n=1002) and Faculty (n=495) | Identification of misconceptions related to genomics concepts  |
| Shuster, 2011 | US | Mixed methods | Nursing students (n=452) | Assessing the impact of genetics and genomics education on knowledge and attitude |
| Vandiver et al., 2022 | US | Quantitative | Nursing students (n=116) | Exploring knowledge gains following molecular modelling |
| Ward, 2011 | US | Quantitative |  | Developing a tool (Genomic Nursing Concept Inventory - GNCI©) to measure understanding of key genomics concepts |
| Ward et al., 2014 | US | Quantitative |  | Developing and evaluating the GNCI© |
| Ward et al., 2016, A | US | Quantitative |  | Refining the GNCI© |
| Ward et al., 2016, B | US | Quantitative |  | Revising and validating the GNCI© |
| Ward et al., 2018 | US | Quantitative |  | Evaluating the GNCI© |
| **Study type 2. Exploring the integration of genomics across pre-registration nursing curricula** |
| Aiello, 2017 | US | Literature Review |  | Overview of effectiveness of the integration of genomics education and an overview of challenges faced by faculty integrating genomics education |
| Cashion, 2009 | US | Editorial |  | Recommendations to improve integration |
| Collins & Stiles, 2011 | US | Quantitative | Nursing schools (n=103) | Measuring the effects of school characteristics on perceived barriers to integration and perceived levels of student knowledge and competence  |
| Connors & Schorn, 2018 | US | Editorial |  | Recommendations to improve integration |
| Daack-Hirsch et al., 2011 | US | Literature review |  | Reviewing curricular change efforts to inform recommendations to initiate curricular change |
| Daack-Hirsch et al., 2013 | US | Mixed methods | Nursing schools (n=5) | A case study documenting experiences of integrating genomics education across curricula, including measuring faculty knowledge using a tool |
| Dewell et al., 2021 | Canada | Qualitative   | Nursing student (n=19) and Faculty (n=2) | Exploring attitudes to adding genomics content to undergraduate nursing curricula |
| Jenkins & Calzone, 2012 | US | Quantitative | Faculty (n=167) | Surveying faculty readiness to change  |
| Hetteberg & Prows, 2004 | US | Checklist |  | Recommendations to support integration |
| Kirk et al., 2011, A | UK | Report |  | Task and finish group report to assist the Nursing & Midwifery Professional Advisory Board in identifying challenges to integrating genomic healthcare into professional education |
| Kirk et al., 2011, B | UK | Quantitative |  | Exploring the interaction between the integration of genetics-genomics competencies into nursing curricula and regulatory standards |
| Lea & Monsen, 2003 | US | Literature Review |  | Report on successful initiatives since 1995 resulting from efforts of national organisations to advance the diffusion of genetic knowledge and genomics in nursing education |
| Nicol, 2002 | New Zealand | Quantitative | Nursing schools (n=16) | Measuring the extent of genomics education in New Zealand nursing schools |
| Prows et al., 2005 | US | Commentary |  | An overview of international efforts to integrate genomic across nurse education programmes |
| **Study type 3. Exploring genomics educational interventions and resources** |
| Calzone et al., 2011 | US | Literature Review |  | Gap analysis of educational resources |
| Dumo et al., 2020 | Finland & The Philippines | Quantitative | Nursing students | Protocol for a randomised controlled trial to evaluate the effectiveness of a web-based pre-registration genomic nurse education intervention  |
| Elliott, 2019 | US | Commentary |  | Describing an educational session designed to meet a specific genomic nursing competency |
| Fater, 2014 | US | Commentary |  | Describing a genomics learning activity  |
| Garcia et al., 2011 | US | Literature Review |  | Describing strategies used to teach genomics and facilitators and barriers to integration |
| Kim & Han, 2010 | Korea | Quantitative | Textbooks (n=165) | Examining the genomics content in Korean textbooks |
| Kirk et al., 2014 | UK | Report |  | Reviewing a genetics education framework |
| Lopes-Júnior et al., 2022 | Brazil | Quantitative | Nursing programmes (n=138) | Investigating how genetics and genomics have been taught in undergraduate nursing programs  |
| Parviainen, 2023 | Finland & The Philippines | Quantitative | Nursing students | Randomised controlled trial measuring the effectiveness of a web-based genomics education intervention using a tool |
| Pence, 2020 | US | Commentary |  | Highlighting the use of an online resource (Telling Stories) to enhance a pathophysiology class |
| De Sevo, 2010 | US | Commentary |  | Suggesting resources to improve faculty genomics knowledge |
| Sharoff, 2015 | US | Commentary |  | Discussing practical suggestions for the provision of undergraduate nurse genomics education |
| Smania et al., 2022 | US | Quantitative | Faculty (n=88) | Assessing the impact of a genomics education programme |
| Tonkin et al., 2011 | UK | Commentary |  | Exploring the creation and use of genomics education resources |
| Ward, 2017 | US | Qualitative | Nursing students (n=15) | Exploring difficulties experienced by students learning about genomics |
| Williams et al., 2011 | US | Commentary |  | Suggesting strategies to develop faculty genomics knowledge |
| **Study type 4. Sources exploring the development or use of genomics nursing competencies** |
| Consensus Panel on Genetic/Genomic Nursing Competencies, 2009; | US | Competency Framework |  | Competencies and outcome indicators written by faculty from a range of nursing schools (n=171) for educators to guide educational activities to meet genomics nursing competencies |
| Greco & Salveson, 2009 | US | Literature Review |  | Summary of published recommendations for genetics and genomics competencies |
| Rodrigues, 2016 | Portugal | Congress item |  | Highlighting the need to improve genomic literacy and the use of core competencies within health professional education |
| Seibert, 2020 | US | Literature Review |  | Tracing the development of genomic nursing competencies and exploring the literature related to nurse genomics education |
| Thompson & Brooks, 2011 | US | Quantitative |  | Surveying how the US Essential Nursing Competencies and Curricula Guidelines in Genetics and Genomics (Essentials) were being achieved in the US |
| Trossman, 2006 | US | Commentary |  | Discussing the American Nursing Association (ANA) genomic nursing competencies (2005) |
| **Study type 5. Other** |
| Chair et al., 2019 | Hong Kong, Taiwan and mainland China | Literature Review |  | Review of current genomics practice to inform recommendations for nurse education |
| Finneran, 2014 | US | Letter |  | Letter to the editor of a student forum |
| De Jesus & Mitchel, 2016 | US | Student Voice article |  | Highlighting the need for consistent genomics education |
| Lea et al., 2011 | US | Literature Review |  | Overview of advances in genetics and genomics in the context of nursing |
| Pestka & Williams, 2005 | US | Commentary |  | Discussing the achievements of the International Society of Nurses in Genetics (ISONG) |
| Whitley et al., 2020 | US | Literature Review |  | Exploring the importance and benefits of genomics education |

*Table 3. Examples of genomics skills and knowledge perceived as essential*

|  |  |
| --- | --- |
| Taking a family health history  | Aiello, 2017; Adejumo et al., 2021; Collins & Stiles, 2011; Daack-Hirsch et al., 2013; Dewell et al., 2020; Dewell et al., 2021; Garcia et al., 2011; Greco & Salveson, 2009; Hsaio et al., 2011; De Jesus & Mitchel, 2016; Lea & Monsen, 2003; Lopes-Júnior et al., 2022; Munroe & Loerzel, 2016; Prows et al., 2005; Read & Ward, 2016; Read & Ward, 2018; Sharoff, 2015; Shuster, 2011; Tonkin et al., 2011; Trossman, 2006; Vandiver et al., 2022; Ward, 2011; |
| Risk identification in patients and family members | Adejumo et al., 2021; Collins & Stiles, 2011; Dewell et al., 2021; Hsaio et al., 2011; Lea & Monsen, 2003; Lea et al., 2011; Lopes-Júnior et al., 2022; Read & Ward, 2018; Trossman, 2006; Ward, 2011; |
| DNA structure and function | Adejumo et al., 2021; Daack-Hirsch et al., 2011; Hsaio et al., 2011; Hetteberg & Prows, 2004; Lea & Monsen, 2003; Lopes-Júnior et al., 2022; Munroe & Loerzel, 2016; Nicol, 2002; Read & Ward, 2018; Sharoff, 2015; Trossman, 2006; Vandiver et al., 2022; Ward, 2011; Ward, 2017; |
| Genetic variation (or diversity), pathology and inheritance patterns of common disease | Adejumo et al., 2021; Calzone et al., 2011; Daack-Hirsch et al., 2011; Dewell et al., 2021; Hetteberg & Prows, 2004; De Jesus & Mitchel, 2016; Kawasaki et al., 2021; Majstorović et al 2021; Munroe & Loerzel, 2016; Nicol, 2002; Parviainen et al., 2023; Read & Ward, 2016; Read & Ward, 2018; Sharoff, 2015; Shuster, 2011; Smania et al., 2022; Tonkin et al., 2011; Vandiver et al., 2022; Ward, 2017; |
| Accessing information, translating genetic information (including test results) to the public and supporting people to make decisions | Adejumo et al., 2021; Dewell et al., 2020; Hsaio et al., 2011; Jaekel, 2012; Kirk et al., 2011, A; Lea & Monsen, 2003; Lea et al., 2011; Majstorović et al 2021; Seibert, 2020; De Sevo, 2010; Ward, 2011; Ward et al., 2016, A; |
| Cultural competency | Calzone et al., 2011; Daack-Hirsch et al., 2013; |
| Direct to consumer testing | Calzone et al., 2011; Connors & Schorn 2018; Lea & Monsen, 2003; |
| Types and utility of genomic screening, tests and other diagnostic procedures  | Cashion, 2009; Daack-Hirsch et al., 2011; Jaekel, 2012; Lea et al., 2011; Lopes-Júnior et al., 2022; Majstorović et al 2021; Pence, 2020; Read & Ward, 2018; Sharoff, 2015; Seibert, 2020; Smania et al., 2022; Thompson & Brooks, 2011; Ward, 2011; |
| Targeted treatment modalities | Connors & Schorn 2018; Hsaio et al., 2011; Lea et al., 2011; Lopes-Júnior et al., 2022; Nicol, 2002; Parviainen et al., 2023; Pence, 2020; Prows et al., 2005; Read & Ward, 2018; Rodrigues, 2016; Thompson & Brooks, 2011; Tonkin et al., 2011; Ward, 2011; |
| Navigating legal, cultural, psycho-social and ethical issues | Daack-Hirsch et al., 2011; Daack-Hirsch et al., 2013; Dewell et al., 2020; Elliott, 2019; Fater, 2014; Hsaio et al., 2011; Hetteberg & Prows, 2004; Jaekel, 2012; Kim & Han, 2010; Kirk et al., 2011, A; Kronk et al., 2018; Lea & Monsen, 2003; Lea et al., 2011; Lopes-Júnior et al., 2022; Nicol, 2002; Parviainen et al., 2023; Read & Ward, 2016; Read & Ward, 2018; Sharoff, 2015; Smania et al., 2022; Tonkin et al., 2011; |
| Pharmacogenomics | Fater, 2014; Hetteberg & Prows, 2004; Kim & Han, 2010; Lea et al., 2011; Lopes-Júnior et al., 2022; Munroe & Loerzel, 2016; Sharoff, 2015; Shuster, 2011; Trossman, 2006; Smania et al., 2022; Tonkin et al., 2011; Ward, 2011; |
| Health promotion  | Garcia et al., 2011; De Jesus & Mitchel, 2016; Parviainen, 2023; Lopes-Júnior et al., 2022; Pence, 2020; Prows et al., 2005; Sharoff, 2015; Trossman, 2006; Thompson & Brooks, 2011; |
| Knowledge about specific genetic conditions | Hsaio et al., 2011; Lopes-Júnior et al., 2022; Pence, 2020; Sharoff, 2015; Smania et al., 2022; Tonkin et al., 2011; |
| Referral to and collaborative working with appropriate professionals including facilitating patient access to services | Hsaio et al., 2011; Lea & Monsen, 2003; Lopes-Júnior et al., 2022; Parviainen et al., 2023; Pence, 2020; Read & Ward, 2016; Read & Ward, 2018; Seibert, 2020; Sharoff, 2015; Thompson & Brooks, 2011; Ward, 2011; |

*Table 6. Supporting statements from included sources*

|  |  |  |  |
| --- | --- | --- | --- |
| Theme | Key point | Example of a supporting statement  | Author(s) and source type |
| 1. **Approaches to integration**
 | A curricular thread represents effective integration of genomics, permitting a wider range of content relevant to practice | ‘It was identified thatpsychosocial needs; ethical, legal, social implications; ethnic, racial, cultural considerations for providing genetic services; genetic resources related to genetic information and technology could be integrated intoethics, professional foundations, community, social/cultural/political, health care systems, maternity/newborn,child health, adult health, and mental health nursing courses’ | Hetteberg & Prows, 2004ChecklistQualitative research findings underpinning the checklist |
|  | Mapping existing or planned curricular content against a genomics competency framework is useful to check whether key content has been included | ‘The “Essential Nursing Competencies and Curricula Guidelines for Genetics andGenomics” is a useful instrument for guiding the incorporation of genetics and genomicsinto nursing curricula and practice. The specific genetic/genomic competencies can also be used to guide curriculum assessment and planning…’ | Lopes-Júnior et al., 2022QuantitativeStatement by authors within discussion of study findings |
|  | Faculty genomics champions can be useful for integration, but they can feel over-burdened which can lead to a lack of motivation | ‘Recommended changes [to the Genomics Faculty Champion Initiative] included (1) creation of centralized talent, (2) need for more than 1 person to effect change, (3) creation of regional champions, (4) creation of regional workshops, and (5) release time and financial support for the Faculty Champion’ | Jenkins & Calzone, 2014QualitativeSummary of recommendations made by participants (organisational leaders) |
| 1. **Pedagogical approaches**
 | It is important to consider pedagogical approaches which facilitate the construction of student knowledge and knowledge retention | ‘Conceptual learningencompasses a deeper, more meaningful understanding that is linked with other concepts, can be recalled later, and can be applied to different contexts’ | Dewell et al., 2020QuantitativeContextual statement underpinning the research |
|  | Effective resources can be helpful for faculty teaching genomics | ‘Nurse educators with lim­ited experience in teaching genetics may benefit from resources to help bring real­ism and relevance to the topic of genetics in the classroom’ | Pence, 2020CommentaryAuthor’s opinion |
|  | A range of interactive teaching activities contributes to student learning | ‘Providing a varietyof learning strategies, engaging students intellectuallyas well as motivationally, succeeded in achieving the learningoutcomes’ | Sharoff, 2015CommentaryStatement based on author’s experiences |
| 1. **Application to practice**
 | Practice experiences are important for student application of theory to practice and development of confidence and core skills | *‘I believe that, as a new nursing student, the one genetic nursing competency that I displayed the most progress with throughout the semester was the ability to identify clients who may benefit from specific genetic and genomic and/or services based on assessment data. I remember seeing a young patient with breast cancer, and at the time I immediately wondered whether anyone had educated her on the potential genetic components of the disease’*  | Kronk et al., 2018Mixed methodsDirect quotation from primary participant (student) |
|  | Clinical simulation and role-play can facilitate application to practice and improve confidence in a ‘safe’ environment | ‘Students’ ability to answer higher-level application questions within the different subscales may be the result of practicing these skills and receiving feedback in recent nursing courses’ | Munroe & Loerzel, 2016Mixed methodsExtrapolation based on research findings |
| 1. **Approaches to assessment**
 | Assessment of student learning is largely centred around knowledge gains but should also extend to assessing student *understanding* of key concepts to determine the effectiveness of education | ‘Research in genetics education has uncovered a number of misconceptions sufficiently pervasive to be found in multiple studies… Understanding student misconceptions fosters effective teaching by providing targets for instructional remediation and anchors for instructional strategies’ | Ward, 2017QualitativeContextual statement underpinning the research (supported by multiple sources) |
|  | Effective assessment tools would enable educators to better assess whether learning had been achieved through the education provided | ‘Valid and reliable instruments will assure nurse educators thatthey can measure the efficacy of genomic nursing curriculumand different teaching modalities across diverse student andRN populations’ | Anderson et al., 2015Literature reviewConclusion drawn from the literature |
| 1. **Approaches to evaluating education**
 | Teaching strategies should be evaluated using effective methods to determine effectiveness and to help improve and develop them | ‘Evaluationmethods play a key role in assessing the availability, reliability,and validity of strategies, along with practicality for integrating strategies into undergraduate and graduate nursing curricula.Evaluation issues may be one reason why educators are slow toadopt the teaching strategies reported in the literature’ | Garcia et al., 2011Literature reviewInterpretation of findings from the literature |
|  | The integration of genomics across nursing programmes should be evaluated to support development in this area | ‘The actual evaluation of the school curricula with a checklist instead of reported format should be considered in the future’ | Adejumo et al., 2021Mixed methodsRecommendations based on research findings |
|  | The sharing of curricular models and well-evaluated teaching strategies would be useful for faculty and may help to standardise provision | ‘Extending current collaborative efforts can resultin mechanisms for globally sharing exemplars for integratinggenetics in various levels of nursing curriculum’. | Prows et al., 2005CommentaryAuthor recommendation based on knowledge and experience |