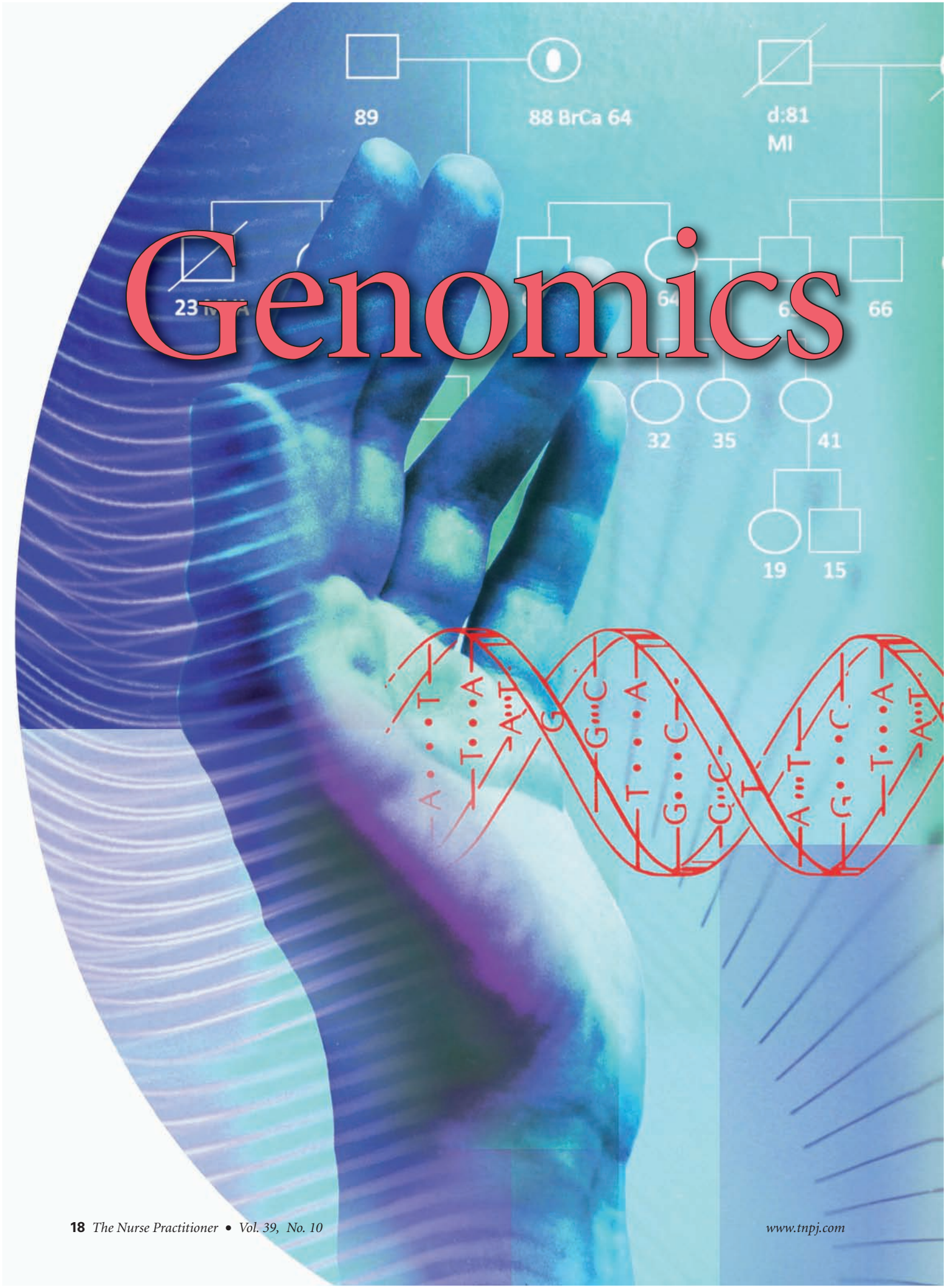

Genomics

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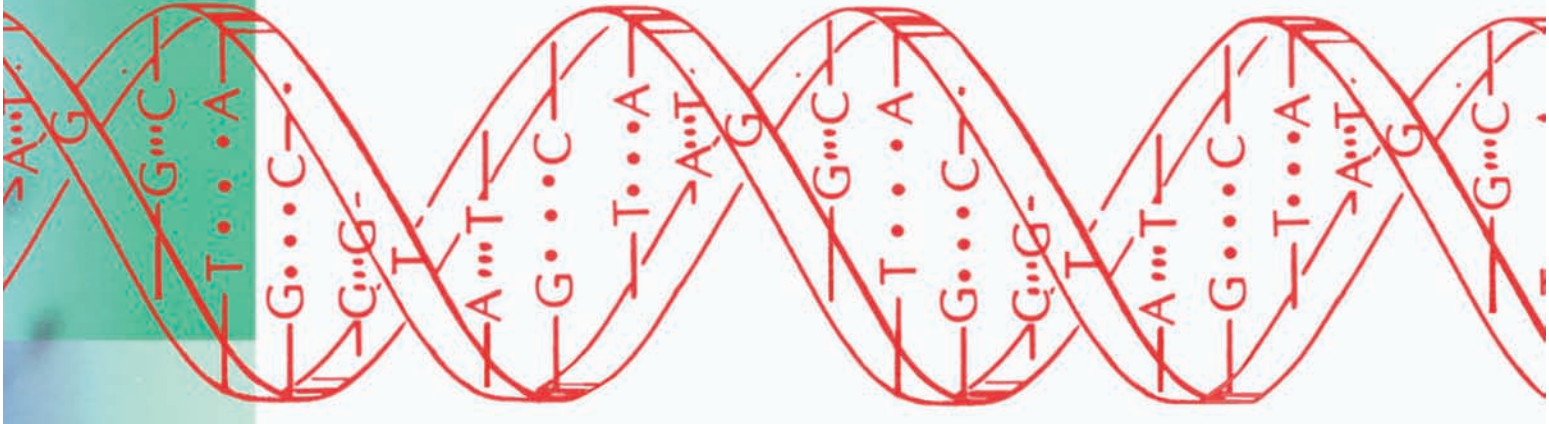
Abstract: The public expects nurse practitioners (NPs) to be informed about scientific advances and adjust practice as disease screening and management evolves with new research findings. No discipline has evolved more quickly than genomics. This article describes six areas in genomics in which NPs should be competent, concluding with three case studies.

By Diane C. Seibert, PhD, CRNP, FAANP, FAAN



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The scope of nurse practitioner (NP) practice has expanded steadily since Dr. Loretta Ford partnered with Dr. Henry Silver in 1965 to launch the first NP program. Over the past 50 years, NPs have become key players in virtually every healthcare setting, treating patients from preconception to death. With each patient encounter, NPs play a key role in supporting the nation's health collecting detailed health histories, conducting physical exams, ordering diagnostic tests and treatments, and referring patients to appropriate healthcare partners. The public has come to expect excellence from NPs, and part of an NP's job is to maintain clinical competency by staying informed about scientific advances and adjusting practice as disease screening and management change with new research findings.

Like all healthcare professionals, NPs must keep up with the demands of clinical practice while protecting quiet time to absorb new information. Over the past two decades, no discipline has evolved more quickly than genomics, and in no other domain do so many nurses and NPs report feeling ill-prepared to engage because they believe their baseline preparation and knowledge is weak.[1] To address the practice/

Keywords: family health history, genetics, genomics, human genome, nurse practitioner practice

knowledge gap among nurses, online resources, programs and competencies were developed (see *Resources*). The first set of competencies, "Essentials of Genetic and Genomic Nursing: Competencies, Curricula Guidelines, and Outcome Indicators" was published in 2006 and revised in 2009.[2] That same year, a group of advanced practice registered nurses began developing an expanded set of genetic/genomic competencies to guide the practice of nurses prepared at the graduate level. These competencies, the "Essential Genetic/Genomic Competencies for Nurses with Graduate Degrees" published in 2012, apply to nurses with advanced degrees in nursing, including, but not limited to, advanced practice registered nurses, clinical nurse leaders, nurse educators, nurse administrators, and nurse scientists.[3]

What should NPs know about genomics? Has the "science" of genetics evolved into the "art" of genomic practice enough to make it worth a busy clinician's time to learn more about it? This article uses the framework of the "Essential Genetic and Genomic Competencies for Nurses with Graduate Degrees" to provide NPs with some context and examples of how these competencies can be applied in practice. The article concludes with some case examples to highlight the value of some of the available resources and offers a glimpse into the future of NP practice.

Risk assessment and interpretation

One of the main reasons for collecting a history and conducting a physical exam is to assess risk. The comprehensive history and physical exam provide a snapshot of an individual's current health status while identifying potential health threats before they cause injury or harm.[4] Each time NPs ask patients about their diet, physical activity, risk-taking behaviors, and environmental exposures, they are assessing risk. Unfortunately, the family health history (FHH) is often underutilized in clinical practice.[5] The FHH is a powerful risk assessment tool because it helps identify at-risk individuals, clarifies biologic relationships, and offers the opportunity to estimate risks for Mendelian and multifactorial disorders. A number of barriers to collecting a detailed FHH in nongenetic healthcare settings have been described (lack of time, lack of patient knowledge about their family's history, lack of provider knowledge), but none of these negate the fact that FHH history is critical in providing truly personalized (or precision) healthcare or that NPs need to be competent in collecting, recording, updating, and interpreting the FHH.[5-7]

A basic pedigree should contain information on three generations of family members: the first-degree relatives (parents, siblings, and children), second-degree relatives (half siblings, grandparents, aunts, uncles, and grandchildren), and third-degree relatives (cousins); however, if a genetic disorder is suspected, as much FHH information should be gathered and recorded as possible.[8] Whenever possible, data should be recorded electronically to facilitate retrieval, review, and updating. Electronic healthcare records (EHRs) are ideal for this purpose because relevant information can be simply copied and pasted into the records of related family members. At the time this article was written, however, few EHRs had fully functioning FHH tools built into them.

Genetic red flags

Once the FHH is collected, updated, and recorded, the next step is evaluating the FHH for the genetic "red flags," which increase the suspicion that an individual might be at increased risk for a genetic disorder. Genetic red flags include the following:

- Earlier than expected age of disease onset
- Multiple family members with similar or related disorders, which may or may not follow an identifiable pattern
- Unusual (atypical) presentation of a disorder
- Condition in the less-often-affected gender
- Disease in the absence of known risk factors
- Ethnic predisposition to certain genetic disorders
- Close biological relationship between parents (consanguinity).

Genetic education, counseling, testing, and results interpretation

Once the personal and FHH have been gathered and appraised, findings need to be explained to the patient and/or his or her family taking the practice setting (such as prenatal, pediatric, oncology), the patient's education level, and his or her ethnic, social, cultural, and religious backgrounds into consideration. If genetic testing is indicated, the next decision the NP needs to make is whether they are knowledgeable enough about the genetic disorder to provide truly informed consent to the patient and/or their family. This discussion could take time because the NP would need to explain the risks, benefits, and limitations of a particular genetic test so that patients may decide whether or not they even want the genetic test done. If they decide to go ahead with testing, the NP must then be prepared to order the correct genetic test, provide pre- and posttest counseling, and evaluate the impact of genetic test results on family communication and functioning. A referral to a genetic counselor or medical geneticist is indicated if the NP does not have the time, resources, and/or knowledge to take on all of these roles.

Clinical management

The focus shifts from identifying the condition to developing a targeted screening and management plan when a genetic disorder has been identified. The first thing an NP might

want to do is facilitate a referral to a genetic professional specializing in that particular disorder.[9] These clinical experts can provide detailed information about the disorder, explain inheritance risks, recommend additional testing, develop a treatment plan, and assist in locating a clinical trial. The NP can then develop a comprehensive evaluation and management plan in collaboration with that genetic specialist. NPs also need to remain knowledgeable about the particular disorder so that when new therapies or treatments (gene therapy) become available, the patient may either be referred back to the genetic professional or the NP can engage the patient/family in a dialog about the risks and benefits of the novel therapy. The public has come to expect NPs to provide excellent clinical care but also expect that care will be personalized (incorporating their values) and based on the best evidence.

Ethical, legal, and social implications

Many ethical, legal, and social implication (ELSI) issues emerge when genetic information is applied to healthcare delivery, including concerns related to genetic testing, whole genome sequencing, storage of genetic material, access to genomic information, etc.[10] NPs must be prepared to discuss these issues with patients and their families.[11-14]

Beneficence: Generally defined as "doing good to others," beneficence extends to financial and emotional well-being, life circumstances, expectations, and personal values.

Nonmaleficence: Defined as "doing no harm," nonmaleficence includes the risks associated with surveillance and prevention strategies as well as the risks associated with the potential disclosure of personal medical information if other family members are found to be affected.

Autonomy: Respecting individual preference, usually through the informed consent process. Anytime a genetic test is offered, individuals should be fully informed about the risks as well as the benefits of genetic testing and should be able to choose or decline testing. In most cases, patients are asked to make a follow-up appointment to receive their results directly from the NP, offering the individual one final opportunity to change their mind by not returning to get their results.

Justice: Equal access to genetic services regardless of ethnicity, financial status, or geographic location.

Privacy: Genetic health information should be protected from inadvertent disclosure to third parties. Genetic privacy can be a challenge because of the hereditary nature of many disorders that often has implications for other family members.

Genetic discrimination: Individuals considering genetic testing are often concerned about employment and/or insurance discrimination. The Genetics Information Nondiscrimination Act (GINA), passed in 2008, provides legal protections against genetic discrimination in health insurance and employment. The act protects the genetic information of individuals and their family members but does not offer any protections if someone is symptomatic, is being treated for, or has been diagnosed with a genetic condition. GINA specifically prohibits health insurers from requiring people to provide personal or family genetic information to determine insurance eligibility, coverage, underwriting, or premium-setting decisions. It also prohibits

Resources

Consider bookmarking some of the genetics/genomics resources listed below for future reference.

Baby's first test
www.babysfirsttest.org

Essential Genetic/Genomic Competencies for Nurses with Graduate Degrees
www.genome.gov/Pages/Health/HealthCareProviderSInfo/Grad_Gen_Comp.pdf

G2C2 Genetics/Genomics Competency Center for Education
www.g-2-c-2.org

G3C Global Genetics and Genomics Community
www.g-3-c.org/en

Genetics in Primary Care Institute
www.geneticsinprimarycare.org

GeneReviews
www.ncbi.nlm.nih.gov/books/NBK1116

GeneTests
www.genetests.org/?gclid=CInK6Zf4yLoCFTHxOgod90IAqw

Genetic Testing Registry
www.ncbi.nlm.nih.gov/gtr

Genetics Home Reference
ghr.nlm.nih.gov

Genes in Life
www.genesinlife.org

Genetics Education Program for Nurses at Cincinnati Children's
www.cincinnatichildrens.org/education/clinical/nursing/genetics/default

National Institutes of Health Summer Genetics Institute
www.ninr.nih.gov/training/trainingopportunitiesintramural/summergeneticsinstitute#.UtlPs9go7iw

Ghost in your Genes (five parts)
www.youtube.com/watch?v=toRIkRa1fYU

Georgetown Bioethics
The President's Council on Bioethics
bioethics.georgetown.edu/pcbe/index.html

March of Dimes
www.marchofdimes.com/index.aspx

insurers from using genetic information to make enrollment or coverage decisions. Insurers may not request or require anyone to undergo a genetic test, and genetic information cannot be declared a preexisting condition.

GINA does not provide protection from genetic discrimination in life, disability, or long-term care insurance; it does not apply to members of the U.S. military, to people receiving care through the Veteran's Administration, the Indian Health Service, or the Federal Employees Health Benefits plans. GINA does not preempt state law, so if a state has more expansive genetic protections than GINA, those protections apply. GINA specifically prohibits employers from using genetic information when making employment decisions (hiring, promoting, training, admitting to apprenticeship programs) determining conditions of employment (privileges, compensation, or termination), nor may it be used to limit, segregate, or classify an employee. Employers may not ask for, require, or buy genetic information on an individual or their family member, and labor organizations may not discriminate against, exclude, or expel an individual based on genetic information. GINA does not apply to members of the U.S. military or to employers with fewer than 15 employees and does not interfere with an employer's ability to regulate the workplace environment by using genetic tests to monitor the impact of workplace hazards.

Professional responsibilities

In addition to providing direct patient care, NPs are clinical experts and leaders in healthcare. NPs may be called on to develop educational interventions or professional practice guidelines focused on a genetic disease. NPs also mentor other nurses and healthcare professionals, may be called upon to provide a nursing perspective on clinical or policy discussion involving genetics, and often create organizational climates that are open to exploring and engaging in new healthcare discoveries. NPs help shape healthcare policy at local, state, national, and international levels, and therefore, play key roles in advancing the science and use of genetics. Although not all NPs are directly engaged in generating new knowledge through research, every NP should be focused on applying research findings to improve clinical outcomes.

Case presentations

To help clarify the concepts presented above, three fictitious cases have been created to explore some of the roles and responsibilities for NPs in clinical practice. The FHH will be provided as a foundation for answering a series of questions, and in all three cases, AS is the "proband" (person being studied, asking a question, or person of interest), and her location in the family pedigree is indicated in each case scenario.

Case #1

AS a 32-year-old White female presents requesting "the blood test for breast cancer." Upon further questioning, she says she has a "strong family history of breast cancer," and when she "heard Angelina Jolie's story," she thought she would come in and get tested. This seemingly simple request requires the NP to answer several important questions:

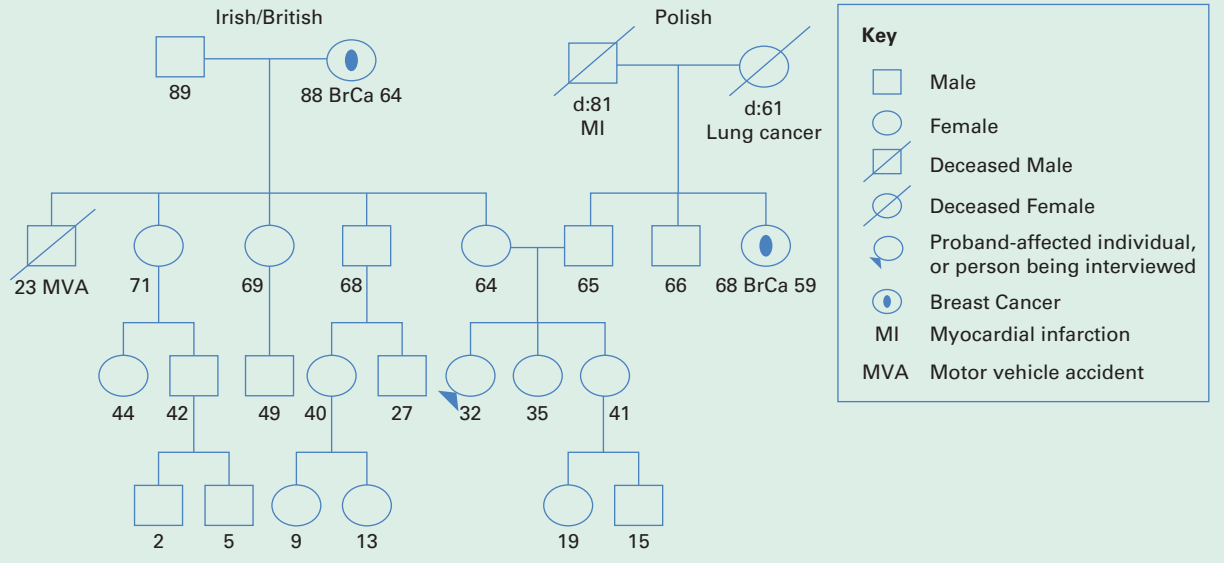
- Are there any "red flags" in this pedigree? (See *FHH scenario #1*.)
- What other data points (assessment, history, diagnostics) should be collected?
- Do other family members need to be tested?
- Should the patient be offered a genetic test? If so, which one?
- Is a genetics referral indicated?
- Who will offer posttest counseling and education?
- Assuming a genetic mutation is found, how will AS's clinical care be affected?
- What ELSI issues should be discussed prior to or after testing?
- Does this case raise any "professional responsibility" issues?

To determine whether AS has a higher risk for developing breast cancer compared to other White women (inherited predisposition), the NP needs to know what the "red flags" are for inherited breast disease:

- Breast cancer diagnosed prior to menopause (50 years of age or younger) (NO)
- Two or more primary breast cancers in one individual or on the same side of the family (NO)
- Ovarian cancer at any age (NO)
- More than two affected family members, one at a young age (NO)
- More than three affected family members at any age (NO)
- Breast cancer in a male relative (NO)
- Triple negative (estrogen, progesterone, and human epidermal growth factor 2 (HER2) receptor negative) breast cancer (UNKNOWN)
- Family history of breast or ovarian and pancreatic cancer (NO)
- Ashkenazi Jewish ancestry (NOT REPORTED)

It is not surprising that AS is concerned that she might be at increased risk for developing breast cancer because she does have two second-degree relatives who have had breast cancer. A closer exam of her FHH, however, reveals that the two family members are on opposite sides of the family (maternal grandmother, paternal aunt), and since there is no evidence of consanguinity, it is unlikely that these two women shared the same deleterious gene mutation. Both women (ages 64 and 59) developed breast disease during the postmenopausal period when most sporadic breast cancers are likely to develop. She did not know the

FHH scenario #1



hormone receptor status (estrogen, progesterone, or HER2 receptor) of either tumor or whether either woman had genetic testing done, and although she denies Ashkenazi Jewish ancestry, it is possible because her paternal lineage was from Poland.

Inconsistent screening. In summary, this FHH is not provocative for inherited breast disease, and no further genetic testing is necessary. AS should be reminded, however, that even in the absence of a familial mutation, one in every eight women (12.4%) born in the United States will develop breast cancer at some time during their lifetime. At the moment, screening recommendations for women at "population" (or average) risk like AS are inconsistent: the American Cancer Society recommends annual mammograms at age 40 and continuing for as long as a woman is in good health; the United States Preventive Services Task Force recommends mammography every other year starting at age 50 and stopping at age 74; and the CDC recommends that women 40 to 49 years discuss screening with their provider and start screening mammography every 2 years between 50 and 74 years.

Case #2:

Are there any "red flags" in this pedigree? (See *FHH scenario #2.*)

- Earlier than expected age of disease onset (YES)
- Multiple family members with similar or related disorders (YES)
- Unusual (atypical) presentation of a disorder (?)
- Condition in the less-often-affected gender (YES)
- Disease in the absence of known risk factors (?)
- Ethnic predisposition to certain genetic disorders (Possibly–Polish)
- Close biological relationship between parents (NO)

The NP does not need to be an expert in hereditary breast and ovarian cancer (HBOC) to recognize the significant red flags in this FHH.

- Breast cancer diagnosed prior to menopause (50 years of age or younger) (YES)
- Two or more primary breast cancers in the same person or same side of the family (YES)
- Ovarian cancer at any age (YES)
- More than two affected family members, one at a young age (YES)
- More than three affected family members at any age (YES)
- Breast cancer in a male relative (YES)
- Triple negative (Estrogen, Progesterone, and HER2 receptor negative) breast cancer (UNKNOWN)
- FHH of breast or ovarian and pancreatic cancer (NO)
- Ashkenazi Jewish ancestry (NOT REPORTED)

AS has several family members on the paternal side who developed breast or ovarian cancer; one first-degree relative (her sister), two second-degree relatives (paternal aunt and paternal uncle), and two third-degree relatives (paternal grandmother and paternal cousin). There are several other red flags in the history: four of the affected women received a premenopausal diagnosis, and her uncle developed breast cancer (another red flag). Although she does not know the hormone status of the tumors or whether she has Ashkenazi Jewish ancestry, it is suspected that she may have

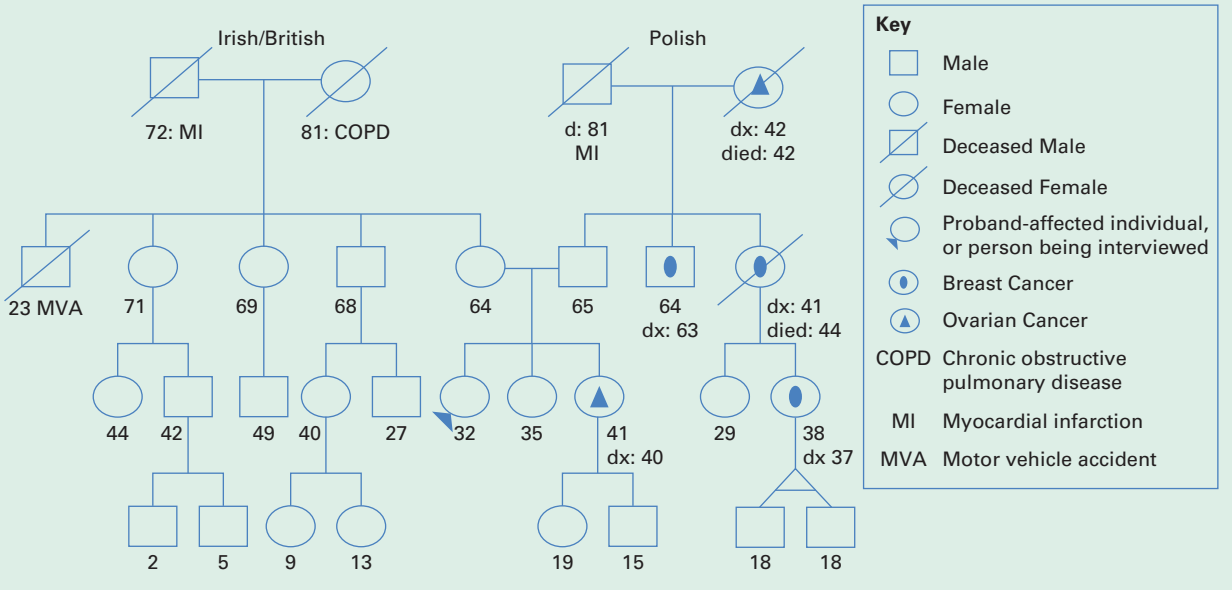
one of the HBOC mutations commonly found in Ashkenazi Jews because her father's family was Polish.

Should AS be offered a genetic test? This version of AS's FHH is suspect for inherited breast and ovarian cancer, and genetic testing would be appropriate. The question is what test to order and who to test. The first question to ask is whether any of her affected relatives had been tested for a HBOC mutation. Genetic testing is fairly straightforward if the putative gene is known; AS can be screened for just the familial mutation. If no one in the family has been tested, AS is not the best person to test; the best person to test is someone with the disease, such as AS's uncle, sister, or cousin, since they have all had the disease but are all still alive. Genetic testing is much more expensive when the familial mutation is unknown because several genes (BRCA1 and BRCA2) have to be tested, and more specific BRCA analysis testing may be necessary as well. It is possible that AS's father has the mutation just like his sister and brother, but since male breast cancer is rare even in HBOC carriers, he may never have a HBOC cancer. On the other hand, he may not carry the mutation at all because he only had a 50% chance of inheriting the deleterious mutation, and AS only had a 50% chance of inheriting it from him if he did.

Is a genetics referral indicated? Although it is certainly possible for an NP to counsel and test AS, this is one of the situations in which it is more appropriate to refer AS to a genetic professional. Although genetic testing is fairly straightforward and relatively inexpensive when the family mutation is known, if the mutation is not known, interpreting the genetic test result can be very challenging. BRCA1 is a large gene, spanning more than 80 thousand base pairs on the long arm of chromosome 17. Over 1,600 deleterious BRCA1 mutations have been identified, some of which are relatively common, but most are unique to one family. BRCA2 spans a smaller region (approximately 10,000 base pairs) on the long arm of chromosome 13 in which more than 1,800 deleterious mutations have been identified.[15] Approximately 3% of people have a "variant of uncertain clinical significance" mutation in BRCA1 or BRCA2 that makes interpreting results even more challenging because these variants may be normal or associated with an increased risk for cancer.[16] Therefore, interpreting genetic test results may be challenging if the clinician does not know which mutations are deleterious, which are benign, and which variants are associated with an increased risk for cancer. Referral to a genetic professional is probably most appropriate in this case because AS and her family will be offered the time and expertise they need to get their questions and concerns addressed.

Do other family members need to be tested? Several other family members should to be offered a genetics referral as well, including AS's father, her 35-year-old sister, her 19-year-old niece, and her 29-year-old cousin. Three other people (15-year-old nephew and the twin 18-year-old sons of her cousin) may also be interested in talking with a geneticist. Although their risk is lower for developing breast cancer because they are male, they may want to know their carrier status for future pregnancy planning. The 18-year-olds may be counseled and offered genetic testing, but the 15-year-old nephew may not be offered genetic testing until

FHH scenario #2



he is legally able to consent (usually age 18), since this disease is not likely to manifest until older adulthood. Children are not typically offered genetic testing for adult-onset disorders unless a treatment is available that prevents or delays development of disease.[17]

If AS does have a deleterious mutation, how will her clinical management be altered? First, the NP should be prepared to communicate the increase in risk in a way that AS can understand it. She may be able to understand statistical risks if they are presented mathematically, but many people grasp these concepts better when a more simplistic approach is used to explain risk (coloring in stick figures, for example). Before risk is discussed, however, a careful review of the literature (or current resources) should be conducted to ensure that the risk numbers being provided are accurate. These numbers adjust over time as knowledge advances. In the case of BRCA1 or BRCA2, the current lifetime risk for developing cancers (by organ system) are:[15]

- Female breast cancer: 40% to 80%
- Male breast cancer: 1% to 10%
- Ovarian: 11% to 40%
- Prostate: up to 39%
- Pancreatic: 1% to 7%
- Melanoma: associated in some studies.

Next, once AS's risk has been communicated, the focus shifts to reducing risk, identifying clinical symptoms as early as possible, evaluating relatives who may be at increased risk, and discussing reproductive risks. These topics are time-consuming, difficult tasks, even for the geneticist who does this on a daily basis. The NP's initial action, as mentioned above, would be to refer AS and her family to a center specializing in the management of women at high risk for HBOC. The "center" model is often the best approach because in one visit, AS and her family may be evaluated by professionals in a variety of disciplines (breast surgeon, oncologist, social worker, plastic surgeon, geneticist) who can then develop a comprehensive management plan that can be communicated back to the NP or the family's primary care providers.

- Enhanced surveillance and risk reduction options will likely be discussed with AS at this consultation. Enhanced screening is usually initiated approximately 10 years prior to the age at which the closest relative was diagnosed. Breast screening in a high-risk women like AS typically includes semiannual clinical breast exams and additional imaging, usually mammography alternating with breast magnetic resonance imaging every 6 months.[18] Screening recommendations for early ovarian cancer detection are difficult because neither pelvic ultrasound nor CA-125 reliably detect early-stage disease even in high-risk women. Risk reduction options that may be discussed with AS include chemoprevention, or surgery (risk-reducing bilateral mastectomy and bilateral salpingo-oophorectomy).
- Several of AS's family members may also be at increased risk for HBOC mutations, so counseling and testing should be offered for other family members to see if they might benefit from increased surveillance.
- Because BRCA1 and BRCA2 are inherited in an autosomal dominant manner, and most carriers also have a carrier parent, AS should be informed that the risk of passing the mutation along to her children is 50% with each pregnancy. Pregestational diagnostic testing and prenatal screening are both available if the mutation in AS's family is known, but additional counseling from a reproductive geneticist is highly recommended.

What ELSI issues should be discussed prior to or after testing? NPs must address several ELSI issues in this scenario. Beneficence is applied when the NP takes the FHH and identifies AS's increased risk prior to the onset of disease. This early recognition of risk offers her the opportunity to discuss options such as enhanced screening, chemoprevention, or surgery before she develops breast or ovarian cancer, improving her longevity as well as the quality of her life. Justice has been applied when AS's family members are offered the same counseling and screening services as AS. The principle of autonomy has been applied when adult family members are offered genetic counseling, testing, and treatment options, but each person has the right to refuse any or all of these interventions. Two ethical constructs, nonmaleficence and privacy, are competing priorities and depend on the preferences of individual family members; these are potentially the most difficult ethical principles to apply evenly.

If everyone in AS's family who is thought to be at increased risk is interested in being counseled and tested, and genetic information is shared freely among family members, then these ethical principles are satisfied; no one is harmed by the information, and the concept of privacy as it relates to BRCA1 and BRCA2 carrier status has been addressed. Maintaining privacy and minimizing harm become more difficult when some (not all) family members want to know their mutation status. The NP needs to carefully discuss the impact and potential harms of keeping a genetic "family secret."[19] Finally, GINA insurance and employment protections against genetic discrimination apply to some but not all family members. AS is protected because she has not been diagnosed with a breast or ovarian cancer, but several of her family members (including her sister) have been diagnosed with cancer, and GINA protections do not apply.

Does this case raise any "professional responsibility" issues? AS could come into virtually any practice setting with her chief complaint, so all NPs need to be prepared to provide basic genetic healthcare. NPs practicing in some

settings (oncology, gynecology) often work regularly with high-risk families like AS's and may find themselves developing targeted educational programs, networking with genetic professionals, developing professional practice guidelines, or working on national policies focused on HBOC. NPs with more knowledge and experience in caring for patients with HBOC may want to share their knowledge through presentations at professional meetings, through publications, or through community outreach efforts. NPs may also become involved in HBOC research either by seeking grant funding themselves or through participation in research if their practice becomes involved in a multisite study.

Case #3:

Are there any "red flags" in this pedigree? (See *FHH scenario #3.*)

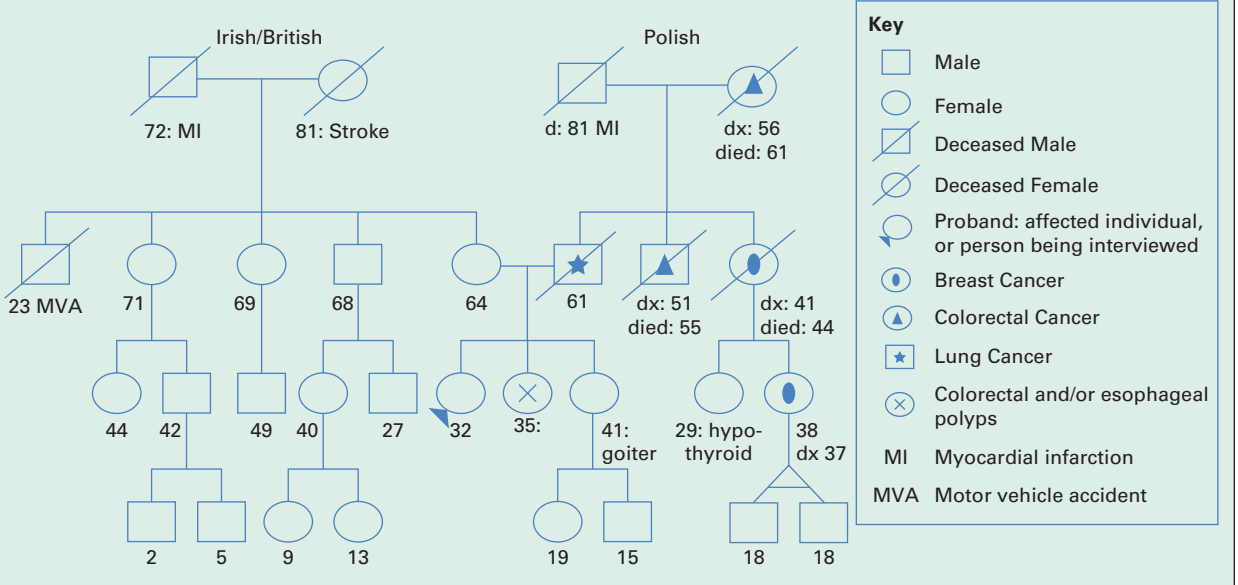
- Earlier than expected age of disease onset (YES)
- Multiple family members with similar or related disorders (YES)
- Unusual (atypical) presentation of a disorder (?)
- Condition in the less-often-affected gender (NO)
- Disease in the absence of known risk factors (?)
- Ethnic predisposition to certain genetic disorders (?)
- Close biological relationship between parents (NO)

This pedigree is a bit more confusing because there are some significant red flags in this FHH, but they are not all associated with breast and ovarian cancer. AS has two family members on her paternal side who developed breast cancer at a young age: one second-degree relative (paternal aunt) and one third-degree relative (paternal cousin). She also has two paternal relatives who died at young ages of colorectal cancer; one second-degree relative (paternal uncle) and one third-degree relative (paternal grandmother). Her father, a nonsmoker, died of lung cancer, one sister has been treated several times for colon and esophageal polyps, and the other sister and one cousin have been treated for thyroid disease. A hereditary problem is suspected, but it is not known what it is.

Should AS be offered a genetic test? If so, which one? This version of AS's FHH is suspect for inherited disorder, but the NP is not sure which one it might be. Genetic testing may be appropriate, but the NP is not sure what test to order or who to test. The first question to ask is whether any of her affected relatives have been referred for genetic counseling and testing. Ordering the right test is fairly straightforward if a familial mutation has been identified. Counseling and management could be rather complicated if all the conditions are associated with that one mutation. If no one in the family has been tested, then AS is not the best person to test; the best person to test is someone with the disease. The problem in this family is who to test. Most of her affected relatives have died, although she has a living cousin who has had breast cancer and her two sisters have had some health problems (colon/esophageal polyps and goiter), but the NP is not sure what disorder to test for.

Is a genetics referral indicated? In this version of AS's history, a genetics referral is definitely indicated to try and identify what (if any) mutation is being passed down in the family.

FHH scenario #3



Do other family members need to be tested? If a deleterious mutation is found in AS's family, several family members might benefit from testing; her sisters, her sisters' children, her two female cousins, and her cousin's identical twin boys.

Is any other information (assessment, history, diagnostics) needed? Because this history is not as clear-cut and appears to involve other organ systems (bowel, breast, thyroid, and possibly lung), additional history or physical exam data may provide important clues as to what gene (or genes) might be involved. Affected family members may have unusual skin findings (trichilemmomas, acral keratoses, mucosal lesions), physical features (large or small head circumference), other benign tumors (lipomas, fibromas, uterine fibroids), or cognitive dysfunction (learning disability, intellectual disability).

Who will offer posttest counseling and education? AS and her family would benefit from a genetics referral, and if a genetic mutation is suspected or confirmed, counseling should be done by someone with expertise in that particular disorder.

If AS is found to be a carrier, options may be available depending on the disease treatment and surveillance.

What ELSI issues should be discussed prior to or after testing? There are several ELSI issues to consider in this scenario as well, even if a specific mutation is never identified in AS's family. When an NP takes a detailed FHH and first identifies the possibility of an increased risk, the principle of beneficence is being applied. Early recognition offers AS and her family an opportunity to investigate whether they have a disease-causing mutation, allows them to discuss options such as enhanced screening, opens doors to becoming involved in research or advocacy, and may improve longevity and quality of life. Justice is applied when AS's family members are all offered the same counseling and screening services. Each person has the right to refuse any or all interventions adhering to the principle of autonomy. As in the case above, nonmaleficence and privacy may be competing priorities and may be the most difficult principles to adhere to. If everyone who is thought to be at increased risk is counseled and tested, and information is shared freely, then both privacy and nonmaleficence have been satisfied. Maintaining privacy and minimizing harm become more difficult when some but not all family members want to know their mutation status. As in the case above, GINA insurance and employment protections against genetic discrimination will apply to some family members. GINA protections do not apply to family members who have already been diagnosed with a disease.

Additionally, the professional responsibility issues are identical to case #2.

NPs and personalized healthcare

Clinicians are now expected to work with genetic/genomic information in ways that were inconceivable just a decade ago, and NPs are on the front lines in healthcare. Patients and their families expect NPs to know about new science when it emerges, and they have come to rely on their NP healthcare partners for the best-possible care. "Lack of knowledge" regarding an FHH (because it was not collected) or failure to refer to an appropriate consultant when a disorder is suspected because the NP did not know enough about genetic "red flags" to initiate a referral is not a viable defense when a bad outcome occurs.[20] NPs must be prepared for a practice environment that includes understanding, and when possible, application of genetics and genomics.

NPs should seek out genetic/genomic educational opportunities whenever possible because the field is evolving constantly. Most professional conferences now offer presentations with a focus on genetics. There are several excellent online resources that offer genetic continuing education courses, many of which are free. One excellent resource is Genetics in Primary Care (www.geneticsinprimarycare.org), which aggregates many of the most useful genetics resources for clinicians in one place.

New professional competencies have been published describing basic genetic/genomic skills that all nurses with graduate degrees should be able to apply in their occupational setting.[3] New textbooks focusing specifically on genetics are being published, and "gold standard" textbooks are being revised to include genetic/genomic concepts. In order to take full advantage of the new and exciting information that is emerging in the area of genomics, NPs should be familiar with genetic concepts, such as promoters (often found embedded in areas of the genome previously considered "junk DNA"), epigenetics, biogenomics, and metagenomics.

As the cost of sequencing genes has plummeted, whole genome sequencing is rapidly becoming a reality, and NPs need to be at the healthcare table when decisions are made about when and how to make that transition because it has the potential to profoundly change the way healthcare is delivered. NPs should also be involved in the dialog concerning genomic ethics because many ethical issues remain unresolved. Healthcare informatics will play a key role in archiving, organizing, and possibly interpreting genetic data, so NPs should be at the technology table as well. At the end of the day, however, perhaps the most important role NPs play (and have always played) in the healthcare system is providing their patients and families with information that is appropriate, understandable, targeted, and accessible. NPs should be prepared to fully participate in a future where truly personalized healthcare is possible. NP

REFERENCES

1. Skirton H, O'Connor A, Humphreys A. Nurses' competence in genetics: a mixed method systematic review. *J Adv Nurs.* 2012;68(11):2387-2398.
2. Jenkins JF, American Nurses Association. *Essentials of Genetic and Genomic Nursing: Competencies, Curricula Guidelines, and Outcome Indicators*. 2nd ed. Silver Spring, MD: American Nurses Association; 2009.
3. Greco KE, Tinley S, Seibert D. Development of the essential genetic and genomic competencies for nurses with graduate degrees. *Annu Rev Nurs Res.* 2011;29:173-190.
4. The Free Dictionary. Risk Assessment. *Medical Dictionary for the Health Professions and Nursing*2012.
5. Qureshi N, Carroll JC, Wilson B, et al. The current state of cancer family history collection tools in primary care: a systematic review. *Genet Med.* 2009;11(7):495-506.
6. Valdez R, Yoon PW, Qureshi N, Green RF, Khoury MJ. Family history in public health practice: a genomic tool for disease prevention and health promotion. *Annu Rev Public Health.* 2010;31:69-87.
7. Mirnezami R, Nicholson J, Darzi A. Preparing for precision medicine. *N Engl J Med.* 2012;366(6):489-491.
8. Bennett RL. *Practical Guide to the Genetic Family History*. 2nd ed. Hoboken, NJ: Wiley-Blackwell; 2010.
9. Riley BD, Culver JO, Skrzynia C, et al. Essential elements of genetic cancer risk assessment, counseling, and testing: updated recommendations of the National Society of Genetic Counselors. *J Genet Couns.* 2012;21(2):151-161.
10. Badzek L, Henaghan M, Turner M, Monsen R. Ethical, legal, and social issues in the translation of genomics into health care. *J Nurs Scholarsh.* 2013;45(1):15-24.
11. Kinsinger FS. Beneficence and the professional's moral imperative. *J Chiropr Humanit.* 2009;16(1):44-46.
12. Hand WB, Robinson JC, Creel E. Ethical Issues Surrounding Weight Bias and Stigma in Healthcare. *Online Journal of Health Ethics.* 2012;8(2). http://aquila.usm.edu/ojhe/vol8/iss2/4/.
13. The Privacy Rule. Health Information Privacy 2013. 2013. http://www.hhs.gov/ocr/privacy/hipaa/administrative/privacyrule/.
14. Otlowski M, Taylor S, Bombard Y. Genetic discrimination: international perspectives. *Annu Rev Genomics Hum Genet.* 2012;13:433-454.
15. Petrucelli N, Daly M, Feldman G. BRCA1 and BRCA2 Hereditary Breast and Ovarian Cancer. 1998 Sep 4 [Updated 2013 Sep 26]. *GeneReviewsTM [Internet]*. Seattle, WA: University of Washington, Seattle; 2013.
16. Eggington J, Roa B. Current Variant of Uncertain Significance Rates in BRCA1/2 and Lynch Syndrome Testing (MLH1, MSH2, MSH6, PMS2, EPCAM). Paper presented at: American College of Medical Genetics and Genomics Annual Meeting2012.
17. Caga-anan EC, Smith L, Sharp RR, Lantos JD. Testing children for adult-onset genetic diseases. *Pediatrics.* 2012;129(1):163-167.
18. Smith RA, Manassaram-Baptiste D, Brooks D, et al. Cancer screening in the United States, 2014: a review of current American Cancer Society guidelines and current issues in cancer screening. *CA: a cancer journal for clinicians*. 2014;64(1):30-51.
19. Dancyger C, Wiseman M, Jacobs C, Smith JA, Wallace M, Michie S. Communicating BRCA1/2 genetic test results within the family: a qualitative analysis. *Psychol Health.* 2011;26(8):1018-1035.
20. Black L, Knoppers BM, Avard D, Simard J. Legal liability and the uncertain nature of risk prediction: the case of breast cancer risk prediction models. *Public Health Genomics.* 2012;15(6):335-340.

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The author has disclosed that she has no financial relationships related to this article.

The views expressed are those of the authors and do not reflect the official policy or position of the Uniformed Services University of the Health Sciences, the Department of the Defense, or the United States government.

DOI-10.1097/01.NPR.0000453641.13662.03

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