Title
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Journal
Nursing, 50(8)

ISSN
0360-4039

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Publication Date
2020-08-01

DOI
10.1097/01.nurse.0000684200.71662.09

Peer reviewed

OPEN

Direct-to-consumer genomic testing: Are nurses prepared?

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Abstract: Genomic testing is increasingly common in the consumer marketplace. The role of nurses in educating and counseling patients requires them to be prepared to respond to questions about the results of direct-to-consumer genomic testing. This article describes one individual's reflections upon undergoing this testing, the challenges of interpreting the results, and nursing considerations for integrating these results into clinical practice.

Keywords: direct-to-consumer testing, DTC, genetics, genomics

THE PREVALENCE of genomic research and the introduction of direct-to-consumer (DTC) genomic testing has ushered in an era in which consumers can acquire genetic knowledge that may have healthcare implications.[1,2] Reflecting on one author's experience with DTC genomic testing, this article discusses the challenges in interpreting and integrating these results into clinical practice.

Currently, genomic information can be made available to individuals through their healthcare system or via DTC testing. In either setting, testing can be conducted on single genes, panels of genes, or the entire genome (see *Key terms*). Single gene or panel tests are typically prescribed by a healthcare provider for clinical use and include counseling to interpret the results. DTC testing often assesses the whole genome, and counseling is usually limited to a one-size-fits-all online format. Although DTC testing is initiated by consumers, the results can directly affect their clinical care. Nurses must be prepared to support and educate these individuals.[3,4]

To address this scope-of-practice need, the American Nurses Association published *Essentials of Genetic and Genomic Nursing* to guide

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nursing education related to genomics.[5] However, knowledge gaps related to genomic concepts and their clinical relevance among nurses have been documented.[6] Additionally, the current competencies do not address DTC testing specifically.[5]

One approach to nursing education on the integration of genomic results into clinical practice is through direct DTC testing experience. This approach, which the authors call *ethic of direct experience*, is based on direct, personal experience as an important research tradition.[7,8] In this case, a healthcare professional's personal experience with the DTC process provides a framework to help nurses understand consumer experiences and prepare to respond to DTC test results in clinical settings.

Following her experience with DTC whole genome sequencing, one of the authors (EF) offered insight into the process. EF is a faculty member at a California school of nursing who teaches coursework related to genomics, as well as a trained genomics researcher. Her experience was assessed using a combination of qualitative research methods and autoethnography, a research method that incorporates personal experience and reflection.[9]

Formal, in-depth, semistructured interviews with EF were conducted by a fellow researcher and coauthor (JS) several months before testing, immediately following the release of her results, and several months after the results had been received.[10] EF also engaged in self-reflection exercises such as journaling and memoing.[11] The following considerations were noted: potentially problematic interpretations of both positive and negative results; issues related to the permanent consequences of having one's complete genomic information, known as *forever knowledge*; and the lost ability to opt out of knowledge about genetic risks in the future.

Key terms[20-25]

Allele: different versions of the same gene with slight variations in the DNA

Chromosome: the thread-like structures that make up an individual's DNA

Deoxyribonucleic acid (DNA): an individual's hereditary information, stored as code and made up of pairs of the following chemical bases: adenine, guanine, cytosine, and thymine

Exome: the entirety of all the exons in an individual's DNA

Exon: a single protein-coding section of an individual's DNA

Gene: a basic unit of an individual's heredity, made up of DNA

Genetics: the study of genes and their effect on inheritance, including different traits, conditions, or disorders passed between generations

Genome: the entirety of an individual's DNA

Genomics: the study of the genome and how its components interact with each other

Locus: the location of specific chromosome in a gene; plural: loci

Results and (mis)perceptions

At the time that EF underwent testing, the FDA did not allow private genomic testing companies to provide results related to disease risk directly to consumers. One of the coauthors (HL), an NP colleague and fellow researcher, filled the provider role to receive results and communicate them accordingly. EF reflected that, after the results arrived, their conversation mainly involved trying to develop a mutual understanding as to what the results meant and how they should be interpreted. As such, nurses' previous education on how to convey general test results to patients may not prepare them to discuss results from genetic testing.

Similarly, HL did not feel that she would know how to handle this situation in a clinical setting the way she would if the test were a metabolic panel. Because of the speed at which genomic testing options are being developed, training on interpreting test results has not been widespread; the technology was simply not available to the general public when many nurses were educated. However, by undergoing the experience and receiving the results, both EF and HL had the opportunity to open a dialogue about how nurses can integrate DTC genomic testing into clinical practice.

Not a new paradigm

Due to its immutability and presumed determinism, genetic knowledge is often perceived as singular and unique among health-related information and therefore unlike anything clinicians have encountered before.[12,13] This perception is only partially true, however, as genomic testing shares many characteristics with other diagnostic tests currently in use. Reflecting on her experience, EF noted a potential missed opportunity to educate nurses on how to interpret genetic findings. She acknowledged that genomic testing is not a new paradigm, but rather an existing paradigm applied to a new category of testing from advances in technology and analytics. As such, many fundamental nursing skills in assessing information related to diagnosis and health risks may be applicable in the postgenomic era.

(Over)interpreting positive results

Considering the overall value of her personal test results, EF had been skeptical about how useful they

could be. This was partially influenced by the knowledge that much of genetic predisposition is more complex than the reported results of a few genomewide association studies. Further, environmental factors, such as sun exposure, and individual behaviors, such as tobacco use or level of physical activity, represent an added layer of complexity, as these may affect the way genes are expressed. This means the underlying genome may be even less deterministic without the appropriate context.

EF noted that the ability to contextualize this information may be rare, even among educated healthcare professionals such as nurses. The small effect size, which describes the quantitative measurement of the importance of a scientific event, had influenced the lens through which she viewed her genomic results.[14] One of her concerns was the calibration of other individuals' lenses in terms of where they may be coming from and how they might interpret the results.

Another source of skepticism regarding the utility of DTC testing came from EF's prior knowledge of her health and family history, which was fairly benign. Given her circumstances, the risk of any alarming findings in her genomic results was low, but this pointed to another conundrum: How would others with a more significant family health history react? EF acknowledged that this may be a very different experience for some people; for example, those who may have three women in their family with breast cancer.

(Mis)interpreting negative results

Another concern involved the interpretation of negative results as definitive. EF cautioned about how individuals may interpret the black box (or a lack of a positive result) as a true negative result. For most conditions, a negative result on a known genetic risk factor for a specific condition simply means that a given locus is not a risk factor for that individual. However, this does not mean the individual has no other genetic risk factors for that same condition indicated at other loci.

Genetic knowledge is often perceived as unique among health-related information, but this perception is only partially true.

The emergent nature of genomic knowledge implies that, with further investigation, a negative result received initially may still yield a positive result later. As such, EF wondered if nurses would be prepared to counsel patients about how to interpret the relevance of negative results.

Forever knowledge

The creation and documentation of her genomic data, or forever knowledge, led EF to realize that this information could be referenced later; for example, when examining a genotype for diseases that typically occur in mid-to-late life such as Alzheimer disease. Certain alleles of the apolipoprotein E gene are associated with an increased risk for early-onset Alzheimer disease. DTC genomic testing can readily provide results related to disease risk well before the individual is likely to experience symptom onset. Additionally, EF came to a frightening understanding that this information would permanently represent her entire genome, including all breakthroughs regarding previously unknown or undiscovered genetic correlations and associations between certain diseases and genes.

The indirect application of DTC testing to other biological relatives is another area of concern. EF experienced this in her results. With two healthy children, she had not been particularly worried, but what if they were now potential carriers according to her results? She reflected on the widespread availability of and access to DTC testing within 20 years, as well as the possibility of methods by which to screen potential coparents based on their genomic data.

Difficulty opting out

Until her own experience with DTC testing, EF acknowledged that she did not appreciate how difficult it would be to opt out of knowing. This is the consequence of forever knowledge. For example, after reading her results that corresponded to an increased risk for myoadenylate deaminase deficiency, a metabolic disease that affects the muscle cells' ability to process adenosine triphosphate, she was forced to consider her risk. Additionally, she became more aware of potential symptoms, such as cramping or pain, though many people experience no symptoms at all.[15] This insight helped her to understand the path traveled by others

with results that corresponded to diseases or conditions with a higher impact on quality of life or mortality. It was a perfect example of opening Pandora's box.

The issue is whether or not individuals want to know. Once they have the results, some of it may be clinically actionable and some of it may not. Fortunately, EF does not have the disease, but now it will be in the back of her mind. She noted that the psychological consequences of this information could keep others up at night. Although she did not think it would have that effect on her, she could imagine how varying levels of individual understanding regarding the information could cause anxiety, especially with different or more concerning results, a different age of onset, or different symptoms.

EF's experience underscored the difficulty of knowing, both in advance and in hypothetical scenarios, as well as the emotional and psychological experience of new knowledge. She considered the implications for the informed consent process. Healthcare professionals may think that patient consent covers this hypothetical outcome, but what people think they want may not correlate with how they feel after receiving test results.

The direct experience approach to DTC testing allowed EF to understand the implications of genomic testing for patients. This may help nurses better prepare to integrate this information into clinical practice. Genetic information is widely viewed as deterministic; therefore, genomic data may be perceived and received differently than the results of other health assessments or diagnostic studies. Thus, healthcare professionals cannot simply extrapolate from previously demonstrated reactions to other healthcare information.

EF experienced some of many identified concerns regarding DTC genomic testing, including a shifting time frame for risk perception, the implications for family members and the possibility of cascade screening for hereditary conditions, and an accurate interpretation of the results.[16] However, recent developments related to additional consequences have been highlighted in the media, such as the recent identification of the Golden State Killer, and have added to the potential implications of genetic information.[17]

Many experts in genomic analysis have expressed concern about the ability to truly anonymize aggregated genetic information.

Additionally, regulatory standards on individual privacy and ownership of this information are still lacking, which has resulted in potentially unintended uses of genetic data. For example, during the 2018 apprehension of the Golden State Killer, law enforcement used a publicly available ancestry database to link a DNA sample obtained from a crime scene and identify individuals related to the suspect.[17] The relative who contributed the DNA was unaware that the information could be used to search for matches to DNA collected at crime scenes. While the host company required user permission to upload genetic information, there is no current legislation to enforce this requirement.[17] As such, privacy policies and data security may vary among companies.

Similarly, potential risks arise when companies share purportedly deidentified data. Many experts in genomic analysis have expressed concern about the ability to truly anonymize aggregated genetic information.[18] Given the current lack of regulations, these include the potential to "embarrass, abuse, or discriminate against users or their genetic relatives" based on genetic information for cases in which a company may not have stringent guidelines on the sharing of aggregated data.[18] The regulatory landscape surrounding DTC testing is an important consideration for both individuals and healthcare professionals.

Looking ahead

The direct experience approach provided initial insights into the experience of those undergoing whole genome sequencing in the DTC realm. Insights from this report can help create a framework for future research. A recent primer summarized some known and emerging issues surrounding DTC testing and provided an example framework to integrate growing knowledge related to consumer experience.[19]

In the near future, research on consumer experience may involve applying qualitative research methods to individual interviews or conducting a systematic review on the growing body of literature exploring DTC testing experiences to determine common themes. More extensive research

Resources

American Medical Association: Direct-to-consumer genetic testing
www.ama-assn.org/delivering-care/precision-medicine/direct-consumer-genetic-testing

Centers for Disease Control and Prevention: Consumer genetic testing is booming: but what are the benefits and harms to individuals and populations?
https://blogs.cdc.gov/genomics/2018/06/12/consumer-genetic-testing

Centers for Disease Control and Prevention: Direct to consumer genetic testing: think before you spit, 2017 edition
https://blogs.cdc.gov/genomics/2017/04/18/direct-to-consumer-2

Genetics Generation: DTC genetics: pros and cons
https://knowgenetics.org/dtc-genetics-pros-and-cons

National Human Genome Research Institute: Direct-to-consumer genomic testing
www.genome.gov/dna-day/15-ways/direct-to-consumer-genomic-testing

is required, including research on the emerging need for healthcare systems to educate patients about DTC testing. Given that patient education is already a primary role for nurses, these healthcare professionals are well positioned to fill the gap.

In this article, the authors explored potentially useful themes to guide the development of nursing education. With additional education, nurses may be able to provide counseling and guidance on the utility of DTC genomic testing, as well as help interpreting the results. For example, many DTC tests are not comprehensive for the whole genome; instead, they are limited to the whole exome. In EF's experience, this was recognized as a contributing factor to the overinterpretation of positive results and the misinterpretation of negative results. Even within the exome, understanding of the significance of many genetic variants is limited and the overlap of variants varies between platforms.

Speaking to the issue of forever knowledge, another concern that emerged for EF was consumer understanding of the varying privacy and security policies of DTC genetic testing companies with regard to personal data. Individual test results may be shared in unexpected ways, affecting future generations or assisting with law enforcement. These topics require further research to fully comprehend. EF's personal experience provides a framework for directions in future research on evidence-based approaches for nurses to counsel consumers and patients about their DTC genomic testing results. ■

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The authors have disclosed no financial relationships related to this article.

DOI-10.1097/01.NURSE.0000684200.71662.09