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RESEARCH REVIEW

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The dawn of consumer-directed testing

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As the public's interest in genetics and genomics has increased, there has been corresponding and unprecedented growth in direct-to-consumer genetic testing (DTC-GT). Although regulatory concerns have limited true DTC-GT available without a physician order, the paradigm has shifted to a model of consumer-directed genetic testing (CD-GT) in which patients are researching testing options and requesting specific genetic testing from their health-care providers. However, many nongenetics health-care providers do not have the background, education, interest, or time to order and/or interpret typical clinical genetic testing, let alone DTC-GT. The lines between CD-GT, DTC-GT, and traditional clinical genetic testing are also blurring with the same types of tests available in different settings (e.g., carrier screening) and tests merging medical and nonmedical results, increasing the complexity for consumer decision-making and clinician management. The genetics community has the training to work with CD-GT, but there has been a hesitancy to commit to working with these results and questions about what to do when consumers have more complicated asks, like interpretation of raw data. Additionally, at the rate with which CD-GT is growing, there are questions about having sufficient genetics professionals to meet the potential genetic counseling demand. While there are many complex questions and challenges, this market represents a chance for the genetics community to address and unmet need. We will review the history of the CD-GT/DTC-GT market and outline the issues and opportunities our profession is facing.

KEYWORDS
consumer-directed testing, direct-to-consumer testing (DTC), DNA testing, genetic counseling, genetic testing

1 | INTRODUCTION

Imagine that you and your partner are standing at your friendly neighborhood drug store—or a favorite online version—with an array of genetic testing kits in front of you. You do not really remember much about genetics from high school other than how eye color and blood type were inherited from your parents, but now genetics seems to be everywhere. You have just met with your new OB/GYN about having children and she gave you some pamphlets about genetic diseases and the associated risks. Your partner is a die-hard football fan and has been excitedly talking about ancestry testing after seeing ads during the college Bowl games. You recently saw a feature on the Today Show about how cancer can be hereditary and are curious about whether testing for "the breast cancer genes" might be valuable. Your mother-in-law was just diagnosed with Alzheimer disease and your partner is worried that it might be genetic too. You have heard that DNA is your "blueprint" so genetic testing must be needed to get accurate information about for your medical care, right? Maybe it can even provide a roadmap to better health that can be customized just for you. But what do you do next?

2 | FROM PATIENT TO CONSUMER

The public is finding themselves faced with a dizzying array of options when it comes to genetic testing, resulting in clinicians being faced with new questions and demands from their patients. Simultaneously, the boundaries of direct-to-consumer (DTC), consumer-directed genetic testing (CD-GT), and clinical genetics are blurring as the price points for testing are dropping and testing is being marketed to patients and primary care physicians directly in the context of optimizing health and wellness. This is further compounded by the influx of "personalized medicine," "individualized medicine," "precision health," and the like into discussions on health care.

There is a notable, concurrent shift to acknowledging people as "consumers" of health care rather than "patients" which has also supported the expansion of this complex genetic testing landscape. In

2011, *New York Times* columnist, Paul Krugman, authored an opinion piece quite bluntly called, "Patients are not Consumers." Krugman (2011) identifies multiple concerns including medical ethics and the sanctity of patient–physician relationship, and at the core of his argument he laments, "there's something terribly wrong with the whole notion of patients as 'consumers' and health care as simply a financial transaction." The opposing viewpoint is one that places the individual as a partner in health care. One who warrants "the transparent, actionable information they need to make smart choices about their care" (Greenberg & Tavenner, 2016) and where "the ideal patient experience merges excellent medical care, high-quality outcomes, compassion, and empathy that address the emotional needs of patients" (Rosen, 2016). In the context of this article, the authors find that "consumer" is the most appropriate term as it broadly encompasses all who are exposed to and pursue these testing services.

This terminology seems additionally apt given the direction of marketing and sales of genetics tests via retail stores, both "brick-and-mortar" and online. Within a 4-day timespan ("Black Friday" through "Cyber Monday," November 2017), Ancestry.com sold an estimated 1.5 million DNA kits, a threefold increase compared to the same period in 2016 (Molteni, 2017). During that same time, 23andMe's Ancestry test was one of the top five sellers on Amazon.com (Molteni, 2017).

Given the degree of expansion that genetic testing has achieved in the consumer market, the consumer mindset is of particular importance. A recent article in Lifehacker generated an example of how these lines are blurred in the mind of consumers which then provoked an intriguing conversation on Twitter about the issue. In November 2017, in the context of the holiday shopping season, "What You Should Know Before You Gift Someone a DNA Test," discussed some of the privacy and ethical issues that are not always considered by the average consumer. In the comments, a reader stated, "Bought the $99 one from amazon [sic] the other day from 23andme [sic]. Ancestry and genetic carrier testing. We are planning on trying to have a baby in the spring, and this is a hell of a lot cheaper than the testing through the MD" (snowchi99, 2017). A geneticist shared this comment on Twitter with a horrified tweet, "Oh god, no. People, I have a PhD in genetics and I still went to a genetic counselor for my pregnancy. Personal ancestry tests are NOT a substitute for medical experts" (Raff, 2017). The subsequent discussion in response to the tweet was wide-ranging and included comments about DTC companies making genetic testing more accessible when cost is a concern, situations where the consumer knew more than their providers about the results and the test and examples of how genetic counselors found issues in the family history that "routine" testing would not have identified.

While we health-care providers might like to think that these tests are far off from our day-to-day clinical practices, recent surges in interest indicate that it is not. As the often-quoted William Gibson said, "The future is already here—it's just not very evenly distributed."

3 | CD-GT: DEFINITIONS

To put some clarity into the haziness of this space, it is important to define some of the terms that are being used. Although these definitions may not be consistently used in the same ways, particularly between professional and lay audiences, they help to define the scope of this area. Specific examples of consumer-directed testing, including ancestry studies, clinical genetic testing, and nonmedical genetic studies are provided in Table 1. The example of 23andMe demonstrates how a single test can cross over several of these categories, adding to the complexity of describing and understanding the boundaries of testing.

CD-GT (also referred to as patient directed, patient initiated, consumer initiated, or similar): The practice of selling or marketing genetic testing directly to an individual rather than to their treating health-care providers. While some tests may still require that their

TABLE 1 Selected examples of consumer-directed testing

	Company	Product	Category
DTC ancestry	23andMe[a]	Ancestry Service, Health + Ancestry Service	Ancestry
	Ancestry.com[b]	AncestryDNA	Ancestry
	Helix[c]	Geno 2.0 by National Geographic	Ancestry
DTC nonmedical	23andMe	Health + Ancestry Service	Traits
	Helix	MyTraits Sport by Intelliseq	Fitness
		embodyDNA by Lose It!	Nutrition
DTC genetic testing	23andMe	Health + Ancestry Service	Carrier status, Genetic health
Consumer-directed clinical testing	Color[d]	Hereditary Cancer Test, Hereditary High Cholesterol Test	Genetic health
	Helix	Inherited Cholesterol Test by Admera Health	Genetic health
	OneOme[e]	RightMed Test	Pharmacogenomics

Note. Includes a selection of available tests for ancestry (testing evaluating ethnicity and maternal/paternal haplotypes), nonmedical (e.g., ancestry testing, skills, diet, and exercise), consumer-directed clinical testing (typically LDTs for medical indications and DTC [e.g., carrier screening for genetic conditions performed with FDA clearance]).

[a]https://www.23andme.com/compare-dna-tests/

[b]https://www.ancestry.com/dna/

[c]https://www.helix.com/shop

[d]https://www.color.com/product/color-genetic-tests

[e]https://oneome.com/patient

treating health-care provider or genetic counselor place the order for testing, CD-GT often enables the patient/consumer to order a test kit and/or generate information to share with their clinician. More often, as with the tests in Table 1, an independent third-party health-care provider can or must act as the ordering health-care provider and the treating health-care provider is not involved. As a result, the patient/consumer often has a specific request of the clinician and may have more information about a given test and/or lab than the clinician.

DTC genetic testing (DTC-GT): Testing available to a consumer without any health-care provider engagement. When a test has medical indications (e.g., carrier screening for genetic conditions) as opposed to nonmedical (e.g., ancestry testing, skills, diet, and exercise), the Food and Drug Administration (FDA) has determined that such tests require regulatory clearance due to their definition as medical devices ("a device within the meaning of section 201(h) of the FD&C Act, 21 U.S.C. 321(h), because it is intended for use in the diagnosis of disease or other conditions or in the cure, mitigation, treatment, or prevention of disease, or is intended to affect the structure or function of the body") (Gutierrez, 2013). Therefore, from a regulatory perspective, there is a significant difference between present-day FDA-cleared DTC-GT and traditional clinical genetic testing. The first FDA-cleared DTC genetic test was 23andMe's Bloom syndrome carrier test in 2015 (FDA News Release, 2015). As of 2017, 23andMe also received FDA authorization to market tests for a subset of genetic disease risk tests (e.g., hemochromatosis, alpha-1 antitrypsin deficiency, late-onset Alzheimer's disease) (FDA News Release, 2017).

Clinical genetic testing: In the United States, the majority of clinical genetic testing is offered in the form of a laboratory developed test (LDT). LDTs are "designed, manufactured and used within a single laboratory" and have historically been regulated by the Clinical Laboratory Improvement Amendments, although the FDA may enforce regulatory discretion in the future for complex tests including genetic tests (U.S. Food & Drug Administration, 2017). In this context, testing is health-care provider mediated, generally by the patient's treating health-care provider.

Nonmedical genetic testing: Testing that involves DNA analysis but is not conducted for medical purposes and has been deemed as outside of their purview by the FDA. This includes testing for ancestry, diet and exercise, skills, predilections, and traits.

4 | HISTORICAL CONTEXT

CD-GT, including DTC-GT, has been a contentious issue in the genetics community since its introduction into the marketplace. However, neither the practice of selling tests with complex and potentially sensitive results nor the marketing of genetic tests to consumers outside of the traditional health-care system is recent.

Direct-to-patient marketing for genetic testing preceded DTC-GT by many years but was the first substantial step in the push toward CD-GT. The first occurrence of genetic testing being introduced directly to consumers was in 2002 when Myriad Genetic Laboratories launched a pilot DTC marketing campaign around testing for the *BRCA1* and *BRCA2* genes via television, radio, and print ads in Atlanta, Georgia and Denver, Colorado. While this marketing campaign solely informed the public about *BRCA1* and *BRCA2* testing, much like pharmaceutical advertising, it caused quite a stir in the genetics community including a heated debate at the National Society of Genetic Counselors' Annual Education Conference that year (S. Weissman, personal communication, January 20, 2018). Myriad's campaign was such a polarizing issue at that time that bioethicist Bryn Williams-Jones (2006) commented, "By advertising BRACAnalysis to the general public, Myriad is deploying a technology that is speculative at best, exploiting a climate of genetic determinism and the public's misunderstandings of and anxieties about susceptibility, probability and risk." The Centers for Disease Control (CDC) studied the pilot campaign and found consumers in Atlanta and Denver were more aware of *BRCA1* and *BRCA2* genetic testing compared with survey participants in two cities not exposed to the campaign. Health-care providers in the pilot cities reported more questions about and requests for *BRCA1* and *BRCA2* genetic testing and more tests ordered, but also reported lacking the knowledge to advise their patients about hereditary breast and ovarian cancer syndrome or the appropriateness of testing (CDC, 2004). A cancer genetics center in the campaign area assessed their referral data, as well as the number of patients identified as "high risk" after genetic counseling/risk assessment. They found a 244% increase in referrals from the previous year and a drop in patients considered to be "high-risk" of having a *BRCA1* or *BRCA2* mutation from 69% to 48% (Mouchawar et al., 2005).

The DTC marketing campaign, followed by Angelina Jolie's disclosure of her BRCA mutation status in the *New York Times* (Jolie, 2013) and the role that it played in her subsequent medical treatment plan (Jolie Pitt, 2015), have led to an increased awareness and demand for *BRCA1* and *BRCA2* testing by consumers. There are concerns about undue psychological stress or worry because of the increased awareness (Lowery, Byers, Axell, Ku, & Jacobellis, 2008) or, even worse, cases of individuals getting inappropriate or the wrong medical care because testing was ordered and/or interpreted by a health-care provider who did not understand the genetic test results (Bever, 2017). Ultimately, making consumers aware of the BRCA genes has led to women and men having discussions with family members about cancer, better educating themselves about their cancer risks, potentially leading to increased cancer screening, preventative measures, and/or earlier diagnoses, as appropriate. The awareness that *BRCA1* and *BRCA2* testing can have a dramatic impact on improving cancer screening and prevention prompted Dr. Mary-Claire King, who co-discovered *BRCA1*, to raise the idea of population based screening for *BRCA1* and *BRCA2* mutations (King, Levy-Lahad, & Lahad, 2014).

Marketing genetic testing to consumers was met with concern by many in the genetics community (genetic counselors, medical geneticists, nurses with genetics training, etc.), but there was some reassurance that a health-care provider would still be involved in ordering the testing and managing the results with the corresponding duty of care. In 2008, 23andMe took consumer-directed testing to a new level. Co-

founders Anne Wojcicki and Linda Avey broadly launched a $399 genetic test that *Time* magazine named as the Invention of the Year for "pioneering retail genomics." While DTC-GT had been available for several years, this test was the first to be viewed as affordable and useful as it "estimates your predisposition for more than 90 traits and conditions ranging from baldness to blindness" (Hamilton, 2008).

Despite its novelty in the genetics space, parallels can be drawn between the 23andMe test and the introduction of over-the-counter (OTC) home-based testing for the human immunodeficiency virus (HIV). First cleared by the FDA in 1996, there were concerns about false-negative results or false reassurance during an acute infection, cost, limited access, and a lack of counseling increasing adverse psychological reactions in HIV-positive patients. Nevertheless, consumers and the medical field have accepted OTC home-based HIV testing due to the significant number of advantages of this type of testing including acceptance by high-risk populations, highly accurate results, empowerment for users and decreased stigma, and increased confidentiality and privacy (Wood, Ballenger, & Stekler, 2014). Aside from confidentiality and privacy, it is in these upsides of OTC home-based HIV testing where the similarities between DTC-GT and HIV testing start to diverge.

Unlike HIV testing in which a positive test result would allow an individual to seek medical care from most physicians or health-care providers who could review the results, order a confirmatory test, and consider treatment, the interpretation and management of CD-GT results have always been a challenge. A large percentage of physicians have not heard of DTC-GT or if they have, they have learned of it through the media or internet and not through scientific meetings or peer-reviewed literature (Kolor, Liu, St. Pierre, & Khoury, 2009; Ohata, Tsuchiya, Watanabe, Sumida, & Takada, 2009; Powell et al., 2012). Potentially more important, numerous studies have shown that many nongenetics professionals have trouble interpreting or understanding genetic test results (Evenson, Hoyme, Haugen-Rogers, Larson, & Puumala, 2016). This raised the question of whether CD-GT may lead to over- or under-screening or mismanagement of individuals. Powell et al. (2012) found that ~43% of physicians who were aware of DTC-GT thought that testing was clinically useful to formulate a medical management plan, even though there was no data to support this.

5 | THE REGULATORY LANDSCAPE

Following the wide launch of 23andMe's genetic testing offering in 2008, several other companies marketed similar tests, generally featuring a mix of nonmedical and medical testing (as defined above). As these companies became more prevalent, the scrutiny of the FDA and other regulatory agencies grew tighter.

However, investigations of DTC genetics companies preceded even 23andMe's *Time* magazine accolades. In 2006, the United States Government Accountability Office (GAO) published an investigation of companies offering DTC nutrigenetic testing, defined in the study as "tests [that] purport to analyze a limited number of genes to provide personalized nutritional and lifestyle recommendations," finding that they "mislead consumers" (Kutz, 2006). The GAO subsequently started an investigation of four DTC genetic testing companies that were prominent at the time, assessing the reliability of DTC results for medical claims along with assessments of "supplement sales, test reliability, and privacy policies" (Kutz, 2010). They purchased 10 tests each from four companies, selected five donors and sent two DNA samples from each donor to each company. One sample supplied factual information about the donor and one used false information. Results for identical DNA samples varied between companies and, in some cases, conflicted with the medical or family history of the individual who supplied the DNA (Kuehn, 2010; Kutz, 2010). Coinciding with the release of the Kutz report, the Subcommittee on Oversight and Investigations of the House of Representatives Committee on Energy and Commerce held a hearing on "Direct-To-Consumer Genetic Testing and the Consequences to the Public Health." It was at this meeting that the FDA widely introduced doubt as to whether these tests could be categorized as LDTs and opened a door to regulatory enforcement by the FDA (Direct-To-Consumer Genetic Testing & the Consequences to the Public Health, 2010).

The FDA issued several communications to 23andMe following the 2010 hearing and after failing to respond, the FDA sent them a highly publicized warning letter from in 2013. The letter stated, "you are marketing the 23andMe Saliva Collection Kit and Personal Genome Service (PGS) without marketing clearance or approval in violation of the Federal Food, Drug and Cosmetic Act (the FD&C Act)," and cites specific instances where 23andMe's marketing fell into the medical arena—"For example, your company's website at www.23andme.com/health (most recently viewed on November 6, 2013) markets the PGS for providing 'health reports on 254 diseases and conditions,' including categories such as 'carrier status,' 'health risks,' and 'drug response,' and specifically as a 'first step in prevention' that enables users to 'take steps toward mitigating serious diseases' such as diabetes, coronary heart disease, and breast cancer" (Gutierrez, 2013). While the letter to 23andMe was the most visible, several other companies received similar warnings and all were instructed that corrective action was required and that they must follow a regulated path to offer testing or cease operations. As noted earlier, 23andMe was the only company that has pursued an FDA-cleared path to offer DTC testing to date.

6 | THE IMPACT TO DATE

While regulatory bodies continue to evaluate where and when they have authority to oversee CD-GT/DTC-GT, concerns about testing analytics, clinical utility and both consumer and clinician understanding of this type of testing led to multiple professional organization and panels issuing policy or guidance statements about CD-GT/DTC-GT. Initially, many of these statements addressed issues regarding the: certifications of the labs performing the tests, evidence used to determine which genes or single nucleotide variants (SNVs) to include, lack of evidence-based guidelines for managing results, lack of federal oversight, privacy of genetic test results and consumer data, and potential psychological risks to consumers of CD-GT/DTC-GT (American College

of Genetics and Genomics [ACMG] Board of Directors, 2008; American Society of Human Genetics, 2007; Canadian Medical Association, 2015; Secretary's Advisory Committee on Genetics, Health and Society, 2010). However, in more recent years, some societies have taken a slightly softer tone in their position statements. While some of the topics above are mentioned, much of the focus is on ensuring people have access to a genetics professional either to help with the ordering of testing or for test interpretation (ACMG Board of Directors, 2016; National Society of Genetic Counselors, 2015).

An issue that critics often come back to about CD-GT/DTC-GT is that it might cause excessive anxiety about health or disease predisposition creating a population of "worried well," or that test results may lead to changes in health behavior that may not be justified based on the results (Caulfield, 2011). Stewart, Wesselius, Schreurs, Schols, and Zeegers (2018) recently completed a systematic review and meta-analysis of the literature assessing psychological responses, behavioral changes, and sharing patterns of DTC genetic test results. Overall, psychological responses to DTC results, including worry, distress, and anxiety, were low or absent and those who had a negative response to DTC results experienced a lessening of distress or anxiety overtime. Somewhat surprisingly, one study found that sharing the results with a genetic specialist actually increased anxiety and distress (Bloss, Wineinger, Darst, Schork, & Topol, 2013). Generally, less than a third of people made a self-reported health-related behavioral change related to dietary practices, fat or caffeine intake, vitamin or supplement use, weight loss, alcohol use, smoking, and/or exercise. Of importance, for those who reported making a health-related change, it is not known for how long the change was made or whether the change resulted in any health benefit. Also worth noting, a very small percentage of consumers reported a potentially inappropriate response to the results, such as changing an OTC or prescribed medication. About a third of consumers shared the results with at least one health-care provider. This often led to additional health screenings or follow-up tests, but it is not clear whether these tests were needed or appropriate (Stewart et al., 2018). These results, while cautiously reassuring that a significant number of people are not experiencing emotional or health-related harm from CD-GT/DTC-GT, have mostly been conducted on European Americans who are highly educated and have high income levels. As a result, it is not certain whether these results are generalizable to other consumers undergoing CD-GT/DTC-GT.

An emerging issue is that of raw data analysis and the subsequent impact on clinical care. As detailed by Kirkpatrick and Rashkin, ancestry providers are providing access to the raw data files containing the variant calls from the consumer testing. While these files are flagged as intended for research use only by the testing companies, it highlights another growing area of interest for "citizen scientists" who want to dig into their own data with third-party analysis software (Kirkpatrick & Rashkin, 2017). More recently, a clinical genetic testing laboratory reported their experience with confirmatory genetic testing of DTC results for 49 patients who had findings in clinically actionable genes (e.g., *BRCA1*, *BRCA2*, *CFTR*, and *COL3A1*). Forty percent of the results were not confirmed by the laboratory and of those that were, seven of variants suspected to cause "increased risk" were determined to be polymorphisms by the clinical laboratory (Tandy-Connor et al., 2017). While additional detail about the origins of these discrepancies is needed, it suggests that both variants called by the DTC laboratories and the interpretations provided by third-party raw data interpretation tools must be questioned. More importantly, consumers and health-care providers must be aware of the false-positives that are seen in raw data and recognize that any result stemming from raw data analysis be confirmed in a clinical laboratory before incorporating it into clinical care.

7 | MOVING INTO DAYLIGHT: CHALLENGES AND OPPORTUNITIES FOR GENETICS PROFESSIONALS

Given all the questions and concerns raised surrounding CD-GT/DTC-GT, genetic counselors are aptly suited to support both consumers and health-care providers in navigating CD-GT/DTC-GT testing. Hock et al. published the first study assessing genetic counselors' knowledge and beliefs about DTC testing. Of 312 genetic counselors surveyed, ~50% felt DTC genetic testing was acceptable if genetic counseling was provided. Genetic counselors also agreed that they have a professional obligation to be knowledgeable about DTC genetic testing, know how to interpret results, and whether testing should be limited to a clinical setting. The other ~50% of respondents did not agree with the statements showing a clear fragmentation of how genetic counselors view their responsibility and role in managing patients interested in or who pursued DTC-GT (Hock et al., 2011).

Companies are providing services across a broad range of consumer-directed testing categories (Table 1). Additionally, there is a dichotomy throughout this discussion: the number of laboratories offering and the number of individuals pursuing CD-GT is rising rapidly; however, unlike what was seen with OTC HIV testing, there is a general lack of understanding in the nongenetics medical community about this type of testing and how to manage the results. Simultaneously, the genetics community may not have the time or interest to work with individuals who have pursued DTC-GT, although their training makes them optimally qualified to provide needed education and guidance.

The genetics community needs to be the frontline providers helping consumers and nongenetics providers navigate education, interpretation and management of DTC test results. Genetics providers have the required training to discuss the benefits and limitations of CD-GT/DTC-GT, interpret SNV data in a way that is understandable and meaningful, review residual risk, explain potential implications of test results on medical management, screening, and preventive care, guide individuals about the ramifications of the results for family members in addition to examining whether a confirmatory test is needed. Additional skills will need to be taught to prepare genetics providers for CD-GT/DTC-GT counseling such as understanding the different technologies and methodologies used to perform these tests and how they have changed over time, human genome assembly and the evolution of the genome builds, what type of data the CD-GT/DTC-GT companies provide in a raw data file, and, probably most importantly, how to critically assess and use third-party analysis software for DTC raw data

"interpretation." Having an understanding of these concepts and tools will ready genetics providers to interpret CD-GT/DTC-GT results as well as assess the accuracy of results, especially for consumers who review their raw data file or run it through third-party software. As an example, Family Tree DNA removes some health-related SNVs before providing the raw data file to a consumer (Kirkpatrick & Rashkin, 2017). This would obviously have an impact on the information a consumer might receive and thereby impact the counseling a genetics provider would need to provide to their patient. Therefore, it is up to the genetics societies like ACMG and NSGC and training programs to educate members and students about these tests and tools, as they do for clinical genetic tests, to prepare them for counseling patients who present with CD-GT/DTC-GT results.

But even if the genetics community embraces this new approach, several key questions remain. At the rate that CD-GT is being performed, can genetics providers meet the potential genetic counseling demand? Recent estimates suggest there are >4,200 certified genetic counselors in the United States, approximately 2,800 medical geneticists and at least 350 nurses with genetics training worldwide (data accessed from International Society of Nurses in Genetics [ISONG] directory), many of whom work together or at the same institution (American Board of Medical Genetics & Genomics, 2016; Hoskovec et al., 2017). While the number of genetic counselors has almost doubled since 2006, the Workforce Working Group comprised of representatives from the American Board of Genetic Counseling, the Accreditation Council for Genetic Counseling, the Association of Genetic Counseling Program Directors and the National Society of Genetic Counselors, acknowledged a shortage of genetic counselors compared to the current demand for genetics services (Hoskovec et al., 2017). The profession is actively trying to address the problem. There are currently 29 accredited genetic counseling training programs in the United States and 3 in Canada. Eight new genetic counseling training programs have been recently accredited in the United States, one in Canada and another six institutions have started the process to create a new training program (ACGC, 2018). Conversely, the American Nurses Credentialing Center recently stopped accepting new portfolios for the Advanced Genetics Nursing-Board Certified certification, which many U.S. members of the ISONG have, due to low enrollment (American Nurses Credentialing Center, 2018).

To address workforce issues until there are more trained providers, new service delivery models are being employed (Cohen et al., 2013). In addition to the traditional "brick-and-mortar" in-person genetic counseling services, the virtual health genetics space has been expanding with more hospitals starting to offer this service and the launch of several new companies that provide on-demand access to a virtual genetics provider. As 23 states have licensure for genetic counselors, a small number of the genetic counselors have opened private genetic counseling practices where they may see patients independently, both in-person and virtually. Depending on the rules of the state licensure laws, some of these genetic counselors have the ability to order genetic testing without physician oversight. Both the virtual health companies and private practice genetics providers may very well have the capacity and time to work with CD-GT consumers as the time demands on these providers may not be the same as those who work in the traditional genetics clinic in the hospital setting. As the demands for genetic testing (both clinical and CD-GT) have increased, more genetic testing laboratories have started to provide patients and nongenetics providers access to in-house or contracted genetics providers for post-test interpretation and counseling. Some models have genetic counseling built into the price of the test and others charge a separate fee for the counseling.

Another consideration must be that genetics providers take a leadership role in training other clinicians and setting standards for counseling for CD-GT, enabling them to manage result interpretation, confirmatory testing and other downstream clinical implications as appropriate. In the current landscape, the genetic counseling model for CD-GT can be compared to carrier screening. Since 2017, carrier screening for select conditions has been recommended for all women even though the a priori risk that a woman would be a carrier is reasonably low for in most conditions. Genetic counselors are not typically involved in routine pretest carrier screening counseling and it has become more commonplace for OB/GYNs to order this testing as part of standard clinical care. Moreover, as expanded carrier screening slowly becomes a commonly ordered test, residual risk discussions are becoming less specific since residual carrier risks are not known for many of the conditions tested. Similarly, CD-GT/DTC-GT is not generally pursued because it is medically indicated or recommended by a health-care provider, and most individuals who choose to pursue CD-GT/DTC-GT also have a low a priori risk of having a genetic disorder. Individuals choosing to undergo CD-GT/DTC-GT are often not receiving pretest counseling, though some may choose to speak to a genetic counselor or health-care provider before pursuing testing and some laboratories require a consultation with a genetic counselor before a test can be ordered (Hock et al., 2011; McGrath, Coleman, Najjar, Fruhling, & Bastola, 2016; Wasson, Nashay Sanders, Hogan, Cherny, & Helzlsouer, 2013). Genetic providers who provide post-test counseling for DTC-GT focus the entirety of the counseling on the interpretation of the results and the clinical utility of the risk information provided by the CD-GT/DTC-GT laboratory. They walk individuals through understanding the differences between absolute and relative risk as it relates to SNPs, the uncertainty of how different SNPs for the same condition may or may not interact with each other to modify the overall risk, and how the risk information could potentially be used to modify diet or lifestyle. If the genetics community were to start addressing this issue head-on and provide and/or support education training for nongenetics providers about CD-GT/DTC-GT, other providers could assist consumers with pre- and post-test counseling and for more challenging cases, refer for a consultation with a genetics provider. In the meantime, when an individual is referred from a health-care provider for post-test counseling, this raises an opportunity to educate the referring provider about CD-GT/DTC-GT through follow-up communications.

Another critical piece to this discussion is the cost of genetic counseling and who will pay for the consultation. Despite the benefits of genetic counseling, reimbursement for genetics services remains limited, depending on whether a consultation is being billed under a health-care provider or a genetic counselor. This is primarily because licensed genetic counselors cannot be paid by the Center for Medicare and Medicaid Services (CMS) because they are not currently

recognized as independent nonphysician providers. Outside of the CMS system, genetic counselors can only bill directly for their services using CPT code 96040 (Beebe, Dalton, Espronceda, Evans, & Glenn, 2006), and this applies only in some settings. Reimbursement for this code is minimal and private payers vary in their coverage. One study showed that almost 63% of encounters billed to private payers using code 96040 received some reimbursement (Gustafson, Pfeiffer, & Eng, 2011). However, unlike this study in which there were clear indications for referral and evaluation (i.e., a billable ICD-10 code) there may not always be billable ICD-10 codes because CD-GT/DTC-GT users are generally healthy individuals with little to no family history, leading to several more complex questions. Will a private payer reimburse a genetic counseling session for the 96040 CPT code without a clear diagnosis code? What will reimbursement look like for patients who are insured by a health maintenance organization (HMO) and require a referral, or in states with licensure laws that require a referral to be seen by a nonphysician genetics professional? Will consumers be willing to pay out-of-pocket for these services if not covered by their insurance? Finally, will insurers cover the cost of confirmatory genetic testing when needed? Imagine trying to obtain insurance coverage for a targeted *BRCA1* pathogenic variant based on a SNP identified in a raw data file if there is no family history of breast and/or ovarian cancer. It is already challenging to obtain coverage of genetic testing when there is clear medical necessity let alone when there is no indication when looked at through the narrow lens of the insurance company. Will a lack of insurance coverage be a deterrent for a consumer pursuing confirmatory testing and what would the potential downstream effects of this be with respect to medical management and screening if a confirmatory test cannot be performed? These are significant issues and potential barriers that require discussion and resolution to ensuring that genetic counseling for consumers of CD-GT/DTC-GT can be performed when needed.

8 | CONCLUSION

The landscape of CD-GT/DTC-GT is complex, with a lack of consensus on everything from definitions to regulation to counseling approaches. The exception is in the dramatic uptake of testing that has occurred in the past 10 years. As CD-GT/DTC-GT companies are helping to drive demand, one could argue that they have a responsibility to help their customers interpret and understand the results, either through direct services or referrals. While genetics providers may disagree on the approach or strategy, we must accept that this type of testing is going to be a part of our practices in some form and maintain an open dialog across specialties. Collaboration with the CD-GT/DTC-GT companies, consumers and nongenetics health-care providers must all be evaluated as responsible and quality solutions are needed for the many open issues surrounding this urgent issue.

CONFLICT OF INTEREST

Erica Ramos is an employee of and stockholder in Illumina, Inc. and an advisor to and shareholder in doc.ai. Helix, a consumer-directed genetic testing company is a partially owned subsidiary of Illumina, Inc. Scott M. Weissman is the founder and sole proprietor of Chicago Genetic Consultants, LLC. He is also a member of the Advisory Board of Gimmegene Ltd.

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