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Experiences and Expectations of Clients Who Sought Genetic Consultation for Direct-to-Consumer Genetic Testing Data

THESIS

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MASTER OF SCIENCE

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by

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DEDICATION

To

Harry and Thelma Wu whose memories continue to empower others through their everlasting strength and love.

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ABSTRACT OF THE THESIS

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Dr. Suellen Hopfer, Chair

Direct-to-consumer genetic testing (DTCGT) has captured the attention of many people across the United States. Although much of the information provided can be categorized as "info-tainment", DTCGT companies also report on genetic information previously only obtainable in a clinical setting. Because of this, some consumers have sought clarification from genetic counselors who have specialized knowledge interpreting DTCGT results. As the popularity of SNP-based testing, as well as whole-exome and whole-genome sequencing, grows, so will the number of people who contact these specialized providers. However, there are limited data on the experiences and expectations of this population for counselors to draw on as they develop and grow their practices.

This study utilized semi-structured interviews of eight clients and one genetic counselor who conducts consultations for DTCGT data to provide in-depth description of consumers' journeys with their DTCGT information. Interviews focused on how informant expectations were or were not met throughout the process and what they took away from the genetic consultation. Qualitative data analysis guided by expectancy violation theory

allowed for rich, explorative reporting of this unique population. Themes of seeking information, frustration, questioning, hopefulness, and satisfaction emerged from the interviews and were described in the context of either motivations and expectations or reflections. In line with the desire for concrete information, informants expressed frustration that genetic research often could not provide the answers they desired. Nonetheless, clients reported high satisfaction with the genetic consultation even though it was common for their expectations of the session to be left unfulfilled. Informants expressed more nuanced understandings of their results and many sought additional DTCGT services following the consultation. Informants continue to have concerns about the privacy of genetic information but hope and excitement for the future of genetics prevails as they continue to interact with their data. Accounts from these respondents provide genetic counselors working in this space with insights into client experiences with their DTCGT results. These findings also highlight the continued need for broader genetics education for both the general public and healthcare providers not trained in genetics.

Introduction

Consumer-driven genetic testing has risen in popularity and garnered the interest of millions of people just within the past couple of years [Regalado, 2020]. These direct-to-consumer genetic testing (DTCGT) companies advertise information about ancestry, optimal nutrition, predicted characteristics of an individual, predispositions to multifactorial health complications, and tests for specific genetic conditions, among other more nuanced offerings. Consumers can now easily access sample collection kits from these companies through major e-commerce sites as well as local drugstores and mass retailers across the globe [Jackson et al., 2014]. Many DTCGT companies also participate in shopping holidays like Black Friday by slashing prices or offering upgraded analytics packages. Although the information reported by DTCGT companies must be confirmed with clinical tests before being used to make management and treatment decisions, many consumers see these tests as great tools to screen for genetic predispositions and find answers in their genetic information. After receiving their results, some consumers feel this information needs to be discussed with healthcare professionals such as primary care physicians, nurse practitioners, and genetic counselors [Su et al., 2011]. And so, although the tests are designed for recreational use, these DTCGT consumers are seeking interpretation and advice from practitioners who typically have sparse experience dealing with this type of information.

1.1 History of Direct-to-Consumer Genetic Testing

The landscape of DTCGT has evolved dramatically even though these types of services have only been available to the general public for fewer than twenty years. The

completion of the Human Genome Project in 2003 was the first milestone that allowed direct-to-consumer genetic testing to come into existence. This thirteen-year, $3.8 billion USD project coordinated by the United States Department of Energy and the National Institutes of Health marked the first time a reference sequence for the human genome had been generated [Human Genome Project Information Archive]. With the completion of the Human Genome Project, interpretation and analysis of individuals' genetic information could be conducted much more efficiently for changes in DNA that could explain or cause disease. The establishment of a human reference genome, along with that of other organisms, also put pressure on laboratories to develop technologies that would allow faster extraction of genetic information in order to advance research and clinical understanding [Barba et al., 2014]. Next-generation sequencing (NGS) techniques were just what the field needed to push clinical diagnostic and research efforts forward. This new, faster, more efficient method of sequencing DNA brought the cost of sequencing low enough that entrepreneurs began to recognize an opportunity to provide those who are interested easy access to their genetic information. This type of service also played well into the general public's excitement and eagerness surrounding genetics. The completion of the Human Genome Project had garnered considerable attention from the general public and some consumers were very keen to have their genetic information analyzed. Many expected this accomplishment to mark the beginning of a great revolution in medicine that would not only provide treatments and cures for genetic conditions but also give personal insights to people who sought to optimize their diet and lifestyle. However, what the public, and some professionals, didn't appreciate was how long it would take for genomic data and the associated bioinformatics to come to fruition as personalized genetic medicine. As

consumers ran into obstacles with clinical genetics such as limited access to qualified professionals and restriction of genetic testing to specifically indicated cases, the appeal of DTCGT grew [Allyse et al., 2018; Annas, J.G. & Elias, E. 2014].

The first DTC company was founded in 2005 [Allyse et al., 2018]. Because no regulations were placed on what these genetic tests could report on, a myriad of "health characteristics" such as nutrigenomics, tests for addiction [Borry et al., 2010], and risks for particular health conditions were shared. There was also no oversight regarding the quality of these tests and the validity of the information that was being reported. In 2010, the United States Government Office of Accountability (GAO) documented the findings of their 2006 investigation into DTCGT companies. Five distinct tests were purchased from four different companies. Two separate samples from the same donor were sent for each test, one with demographic information and health history that described the donor and the other with a fictitious profile in which only the donor's gender was preserved. This study documented result discrepancies between identical samples sent to both separate companies and to the same company. Experts in clinical genetics also reviewed audio recordings of conversations between the donors and company representatives. Through this, DTCGT companies were found to be engaging in deceptive marketing, misinformation, and questionable practices [Direct-To-Consumer Genetic Testing and the Consequences to the Public Health, 2010]. Based on these findings, the United States Food and Drug Administration (FDA) sent letters to the four largest DTCG companies stating that their tests constituted medical devices that had not been approved by the FDA. The FDA then followed up on these letters in 2013 by sending cease and desist notices requiring the

companies to halt sales and marketing efforts until the tests passed the FDA standards of a medical device [Allyse et al., 2018].

Since 2013, some DTCGT companies have succeeded in modifying select tests and overall marketing strategies so that they meet FDA standards for medical devices. Following the approval of the first carrier screening test for Bloom syndrome, the FDA has designed regulatory pathways for DTC tests that report information about carrier screening, genetic health risks, and pharmacogenetics [United States Food and Drug Administration, 2019]. In addition, many services have moved toward requiring a physician to sign off on the testing, whether that be the client's physician or one contracted with the DTCGT company [Howard et al., 2012]. In fact, many tests that look more broadly at a person's genetic information, such as whole-exome sequencing (WES) and whole-genome sequencing (WGS) follow this model of physician-ordered DTCGT. WES involves analyzing the parts of a person's DNA that code for proteins that allow human bodies to function properly. WGS analyzes both the protein-coding and non-protein-coding information, essentially sequencing the entirety of a person's genetic information. However, smaller-scale tests that look for specific changes in a person's DNA are still the most widely utilized by DTCGT companies and the most popular options among consumers. These smaller-scale tests identify single nucleotide polymorphisms, abbreviated SNPs, that describe a change in base pair matching at a specific nucleotide position. Regardless of the testing method, DTC companies have come to rely heavily on data from genome-wide association studies (GWAS) which report on the association of SNPs with a disease state or other characteristics a person may display [Manolio et al., 2008]. Given the current understanding of SNPs and the limited diversity of samples

available to researchers, GWAS studies continue to be more applicable to large-scale study and have not been proven to maintain validity on the level of an individual's genetic information. Additionally, GWAS studies are primarily designed to identify associations, not prove causative relationships between SNPs and phenotypes. Nonetheless, they are being used to provide consumers with information about their individual chances to develop a particular condition or have a certain trait [Tam et al., 2019].

In addition to DTC companies that operate genetic testing labs, there are also online services that offer third-party interpretation of the raw data generated by DTCGT companies. To use these, consumers must first request their raw data from the DTCGT company that ran their original sample. Raw data refers to the uninterpreted sequencing data returned after running a DNA sample. It is often returned to consumers in FASTQ [Cock et al., 2010], binary alignment/map (BAM) [Nelson et al., 2019], or variant call format (VCF) files [Clarke et al., 2012] [Schmidt et al., 2019]. Once consumers obtain these files, they can then upload them to third-party services for a fee or even at no cost. For example, a basic report from the popular third-party interpretation company Promethease, which was recently acquired by MyHeritage, currently costs consumers $12 [Promethease]. These services then use an algorithm to match the consumer's raw data points to entries in publicly available databases. The databases themselves consist of variant information, much of which is from GWAS studies, from primary literature. The third-party service then compiles the information available in those databases to form reports for the consumer [Badalato et al., 2017]. Even those who undergo DTCGT for the sole purpose of learning more about their ancestry can obtain their raw data files and run them through these third-party services [Kirkpatrick, B.E. and Rashkin, M.D., 2016]. The algorithms used by these

services return a report with an extensive amount of interpretive information and sources of primary literature pertaining to the variants found. Confusion can easily occur when consumers simultaneously encounter one variant with an "above average risk" yet another variant with a "below average risk" for the same condition [Schmidt et al., 2019]. However, even if these interpretations were more clear-cut, there may be inherent flaws in the raw data itself. Although the validity of whole-exome sequencing and whole-genome sequencing in the DTCGT setting has not yet been evaluated, a recent study reported a 40% false positive rate for SNP-based testing [Tandy-Connor et al., 2018]. This statistic, along with interpretation of the raw data driven solely by algorithmic matching, as opposed to clinical curation, has resulted in clinician distrust of the information DTCGT companies provide to clients, and therefore the information from third-party interpretation sites. Both DTCGT companies and healthcare providers highly recommend clinical genetic testing to confirm any variants found on DTCGT before the information can be used to make clinical decisions. [23andMe, Wang et al., 2017].

1.2 Genetic Counseling

Genetic counselors are healthcare professionals specifically trained to facilitate patient decisions regarding genetic testing, interpret genetic testing results, discuss the implications of these results with patients, and coordinate follow up services [Kirkpatrick, B.E. and Rashkin, M.D., 2016; Middleton et al., 2017]. Traditionally, genetic counselors have worked in outpatient settings affiliated with hospital systems. Sessions with clinical genetic counselors differ slightly in structure depending on the specialty in which an individual is being seen. In general, genetic counselors review a patient's personal medical history and

family history, give information based on their referral and pertinent history, and facilitate a discussion about genetic testing. As the field of genetic counseling continues to expand, counselors can be found working in genetic laboratories, government services, insurance companies, and in private practice serving a variety of different roles [Harris et al., 2013]. Many of those in private practice work as consultants to companies who require someone with expertise in genetics. Additionally, counselors can work directly with clients who have undergone genetic testing through DTCGT companies.

Each counselor who sees DTCGT clients[1] has his or her own style when it comes to triaging clients and structuring their consultations. Clients may reach out directly to the counselors via the counselors' website or through email. The genetic counselor may also receive referrals from a DTCGT testing laboratory that either directly assigns interested clients to a counselor or sends the client's information to the counselor so they can reach out to them. Regardless of the mode of initial contact, the counselor will then review the client's data, conduct research based on what they find, and prepare a plan for the important points they want to address [Schmidt et al., 2019]. Some also contact clients before the session via email to deduce what questions or concerns they may have. As a result of the vast amounts of complex information returned to clients and their varying levels of engagement with those results before the consultation, DTC genetic consultations generally take on a more educational or instructive quality than typically seen in clinical genetic counseling sessions. Although the genetic counselor will choose to discuss particular findings in a client's DTCGT results, or will address the lack of findings, they will

[1] Given the paucity of primary literature surrounding this subset of genetic counseling, this understanding of private practice genetic consultations was mainly informed by conversations with three genetic counselors in private practice who see clients with DTCGT results. Conversations took place from January 2019 through June 2020.

also teach the client how to search and interpret the data given by the DTCGT companies or third-party interpretation sites. If appropriate, outside referrals to clinical genetics services may be made.

It should also be noted that the typical structure of these consultations differs significantly from that of a clinical genetic counseling appointment. A clinic visit with a genetic counselor in a clinical setting usually begins with the collection or review of family history as is pertinent to the patient's referral to genetics [Ulhmann W.R., 2009]. In contrast, a full family history is rarely taken in genetic consultations. The genetic counselor may ask pointed family history questions if something of possible clinical significance arises, but a comprehensive evaluation of a client's family history is not typically warranted. Although follow up appointments are not routinely scheduled after the initial consultation, clients are encouraged to reach back out to the genetic counselor if they have further questions or wish to re-evaluate their data as genomic bioinformatics evolve and more information becomes available. Overall, genetic counselors who provide assessment for DTCGT clients perform a task inherently similar to that of genetic counselors in clinical settings. However, the way they conduct their sessions and the ultimate outcomes of what they hope their clients take away from the appointment differ significantly.

Another difference in the practice of genetic counselors who analyze DTCGT results is the demographics of their clients. Research surrounding DTCGT has reported that the majority of people who seek genetic counseling after DTCGT are Caucasian, female, have completed at least a 4-year degree, and have children of their own [Gollust et al., 2012; Koeller et al., 2017; Roberts et al., 2017]. Whereas clinical genetic counselors typically see patients with a wider range of demographics. This may be, at least in part, due to the fact

that a genetic consultation is often a paid add-on to the analysis package or is only briefly mentioned by the DTCGT companies. Additionally, the majority of companies do not offer genetic counseling services [Harris et al., 2013]. Therefore, clients must be financially willing and especially motivated to seek out professional guidance for their results. One study found that 4% of people who underwent DTCGT pursue genetic counseling for their results [Koeller et al., 2017] while another cited 14% [Bloss et al., 2013]. Of note, the latter of the two studies included participants who, as a part of the study, received genetic counseling free of charge. This low-uptake rate may be alarming to some considering the increasing number of tests that advertise actionable health information. However, these findings are concordant with the lack of information about genetic counseling on most DTCGT company websites [Middleton et al., 2019].

1.3 Position Statements Concerning DTCGT

In the past decade, a number of professional societies in the United States have issued guidelines or statements concerning DTCGT. The American College of Medical Genetics and Genomics (ACMG) states that consumers should be aware of the limitations and benefits of any DTCGT before submitting a sample. Consumers should also consider the impact this information could have for their family and how this information will be stored and shared by the company [ACMG Board of Directors, 2015]. The National Society of Genetic Counselors (NSGC) puts more responsibility on the DTCGT companies to inform their customers of benefits and limitations of their products but also encourages collaboration with genetics professionals throughout the process of DTCGT. They also briefly address the limitations of raw data files and encourage clinical genetic testing to

confirm a variant before any healthcare decisions are made [National Society of Genetic Counselors, 2019]. An American College of Obstetricians and Gynecologists (ACOG) committee opinion addresses many of the same points as the above two societies but also specifically considers the uses of SNP data and pharmacogenetics in the context of DTCG testing [ACOG, opinion 724]. Originally, many of these statements were more discouraging of the use of DTCGT. For example, the first ACMG statement concerning DTCGT published in 2004, states that "genetic testing should be provided to the public only through the services of an appropriately qualified health care professional" [American College of Medicine Genetics Board of Directors, 2004]. However, as the popularity of these services continued to grow, position statements and policies have become less prohibitory and more cautionary.

1.4 Comprehension, Privacy, and Autonomy

Since its advent, direct-to-consumer genetic testing has sparked rich debate among healthcare professionals, ethicists, and consumers. Much of the debate surrounds the provisioning of sensitive personal information that was previously only available to the public through clinical resources. The prevailing concerns from clinicians seem to be proper consumer understanding of the information and accurate interpretation of what these results mean. Some are skeptical that DTCGT companies are providing information that a broad range of consumers can comprehend. Two studies found that the Flesch-Kincaid Grade Level score for most DTCGT websites is between grades 13.9 and 15, and therefore best understood by those who have had some college education [Kincaid et al., 1981], while the average grade level score in the United States is between 8 and 9

[Laestadius et al., 2017; McBride et al., 2010]. Although some consumers share their testing results with healthcare providers, many clinicians have primarily learned about DTCGT through media exposure or internet advertisements instead of through medical literature or healthcare professionals trained in genetics [Ramos, E. & Weissman, S.M., 2018] who are more likely to provide objective and relevant information to clinicians. Many primary care physicians are willing to incorporate the information from their patients' DTCGT results into their care, but lack the education needed to do so in a clinically appropriate manner [Bernhardt et al., 2012].

The privacy of consumers' genetic information has also come under scrutiny. An analysis of thirty DTCGT company websites concluded that these entities do not consistently meet international guidelines for confidentiality, privacy, and secondary use of data [Laestadius et al., 2017]. From a consumer perspective, one study found that 51.8% of people sampled believed that the privacy of their personal genetic information may be breached in the future. But at the same time, 64.8% of the sample were confident that the DTCGT company would not share consumer information without their express permission [Lee et al., 2013]. Of note, some DTCGT companies do share aggregate, de-identified information with third parties. Although this is stated in their privacy policies, there is no way to guarantee that consumers have read these statements before consenting to the testing. It has also been proven that as few as seventy-five SNPs are needed to correctly correlate a genetic sample with an individual [Liu et al., 2004].

Some clinicians worry about the potential negative psychological effects that clients may experience, such as increased stress or anxiety, as a result of undergoing DTCGT without proper pre-test consent and appropriate support following the return of results

[Bloss et al., 2011]. No studies to date have documented long-term increases in these emotions [Nordgren et al., 2014; Stewart et al., 2018]. In fact, no studies have yet emerged that confirm the immense benefits or worst case scenarios envisioned by proponents and opponents respectively [Bloss et al., 2011; McBride, 2015; Roberts, J.S. and Ostergren, J., 2013].

There are also arguments that DTCGT takes away consumers' autonomy because they are often not properly consented prior to testing and do not typically possess sufficient medical genetics knowledge to assess the full scope of possible implications from results. DTCGT company websites often present more information about the benefits of their product as opposed to the risks and limitations [Covolo et al., 2015; Singleton et al., 2012]. Additionally, contract agreements are presented in an online environment which influences consumers to complete transactions quickly without first reading through or understanding the terms [Phillips, A.M., 2017]. However, others have pointed out that the goals of DTCGT are not always to obtain medically actionable information and consumers often ascribe their own significance to the data they receive based on their motivations for pursuing testing [Vayena, E., 2015].

1.5 Current Research on DTCGT Motivations and Expectations

With the growing popularity of direct-to-consumer genetic testing, researchers have sought to learn why consumers are interested in these tests and what they are hoping to learn from them. Many [Nelson et al., 2019; Su et al., 2011; Roberts, S.J. & Ostergren, J., 2013] have reported that DTCGT was sought in hopes of finding new information that would guide or direct healthcare decisions. The type of information consumers are hoping

for range from guidance regarding diet and lifestyle changes to a diagnosis that explains existing ailments. Interestingly, published studies have found that about 20-33% of consumers reported following through with lifestyle or diet changes after receiving DTCGT results [Stewart et al., 2017]. Some consumers have also changed their supplementation regimen and medication without consulting their physicians in response to receiving DTCGT results [Kaufman et al., 2012]. The majority of consumers are also interested to find out more about their ancestral background [Nelson et al., 2019; Roberts et al., 2017]. Other consumers are mainly curious to gain access to and explore their genetic information or hope to advance genetic research by contributing to the pool of available information [Haeusermann et al., 2017]. In fact, this seems to be a common sentiment among those who chose to undergo DTCGT. In a sample of 80 consumers who underwent DTCGT through a single company, 81.5% believed that sharing their personal genetic information for biomedical research is an important individual responsibility [Lee et al., 2013]. These types of consumers are likely to be fascinated by the technology used and the underlying genetic concepts [Su et al., 2011].

Despite, or maybe due to, the many expectations that have been placed on genetic testing, one study of over 1,000 DTCGT clients found that about 40% of people were disappointed that their results were not more informative [Roberts et al., 2017]. However, the study was not designed to capture the reasons why consumers were dissatisfied with the information. It is hypothesized that this initial disappointment with DTCGT results may contribute to the proportional growth of third-party interpretation sites [Nelson et al., 2019]. Of note, many of these studies have been conducted on consumers who have undergone SNP-based testing. Although some information exists about the motivations and

expectations of those who undergo WES and WGS through DTCGT companies, these newer methods still require further research and will be expanded upon in this analysis [Schmidt et al., 2019].

1.6 Genetic Counseling and Expectancy Violation Theory

Although genetic counseling is a relatively new field in the realm of healthcare, many studies have been done to better understand patients' motivations for testing, why they choose to pursue or decline specific genetic tests, and the perceived value of their genetic counseling session. In genetic counseling, it is generally accepted that patients come in with the expectation of receiving information and support in order to make decisions concerning health management or genetic testing [Michie et al., 1998a, 1998b]. Over time, the outcomes of clinical genetic counseling have been refined to establish well-defined goals and outcomes of sessions [Redlinger-Grosse et al., 2016; Veach et al., 2007]. Given that counseling regarding DTCGT results is a newer subspecialty of genetic counseling, it is not surprising that limited studies describing these outcomes for DTCGT sessions exist in the current literature. However, it is important that genetic counselors working in this space understand their clients' expectations so that they can be integrated into the appointment [Davey et al., 2005].

Expectancy Violation Theory (EVT) will be used in this study to establish an understanding of how these expectations are being met by DTC genetic counselors. EVT states that people expect or predict a particular behavior when interacting with others. Unmet expectations, also defined as expectancy violations, can then be perceived as either positive or negative depending on the relationship between the two people and the context

in which the interaction occurs. The perception of the unexpected behavior then influences subsequent communication interactions. EVT also proposes that positively perceived expectancy violations sometimes produce more favorable outcomes than if expectations were met. However, negatively perceived violations almost always produce worse outcomes and therefore hinder interactions [Burgoon, 2015]. In and of itself, an expectation is a cognition formed as a result of the existing social norms between the two parties interacting. Expectations are fluid and change as a relationship evolves. They are therefore subject to the physical, emotional, and psychological circumstances of each interaction [Burgoon, J.K. & Walther, J.B., 1990]. However, there is a difference between an expected and desired communications where those that are "expected" predict what people will do, while those that are "desired" describe what is considered socially acceptable [Burgoon, 2015]. The integration of this theory provides a vocabulary to discuss outcomes and reflections communicated by clients and will also allow for more precise analysis of the transcripts.

1.7 Significance of Research

The aim of this research is to provide rich, in-depth accounts of consumers' experiences with DTCGT and subsequent genetic counseling about these results. Of particular interest is how client expectations evolved throughout their interaction with their DTCGT results and the influence of genetic consultations. Although studies have been done to evaluate why people choose to participate in open sharing of their genetic information [Haeusermann et al., 2017], there has yet to be a study that follows consumers through this unique journey of DTCGT and genetic counseling. Additionally, this sampling

of informants includes a uniquely high proportion of those who have undergone WES instead of the more commonly reported SNP-based DTCGT. Motivations of DTCGT consumers have primarily been documented through survey responses which, although useful, can lack the stream-of-consciousness perspective often gained through qualitative data analysis. It is increasingly important to not only document these interactions, but also learn from them in order to provide better care to consumers. Between 2013 and 2019, it is reported that 26 million people have submitted their samples for genetic testing at DTCGT companies [Regalado, 2019]. Although it is difficult to accurately predict the growth of these services, the information consumers hope to receive is in line with the current interest surrounding precision medicine and reinforces the prevailing social mindset that each person is a unique individual [Du, L. and Becher, S.I., 2018]. As the popularity of these tests grow, so will the requests for genetic counselors to aid in the interpretation of the results.

In addition to describing first-hand accounts from this unique population of DTCGT consumers, analysis of this data is also aimed at providing insights for genetic counselors working in this emerging space. In fact, genetic counselors who work with and study this client population have specifically called for more investigation into the experiences of DTCGT consumers who have undergone genetic counseling in order to better serve this population [Koeller et al., 2017; Schmidt et al., 2019]. As previously stated, it is rare for genetic consultations to require a follow up session or for clients to reach back out to DTCGT genetic counselors. Therefore, counselors have sparse opportunities to receive feedback from their clients and learn what they took away from the sessions. To address this gap in understanding, this study will document the expectations and experiences

leading up to the genetic consultation but will also examine how informants process the information gained in the genetic consultation and apply it to their interactions with their DTCGT data. A better understanding of consumer takeaways can be utilized to guide individual counselor practices but can also be applied to the formation of standardized practice guidelines for DTCGT counselors. Furthermore, a better understanding of this population will benefit other healthcare providers encountering patients who bring their DTCGT results, or even third-party interpretation reports, to appointments by providing context for the interaction. Ultimately, exploration and richer documentation of this consumer population will not only provide insights on how individuals are interacting with their DTCGT information, but also facilitate discussion around how providers can better serve these curious, motivated consumers.

Methods

2.1 Participants and Recruitment

Semi-structured Zoom interviews were conducted between December 2019 and March 2020 with nine participants: eight of whom were clients independently sought direct-to-consumer genetic testing (see Table 1) and one of whom was a genetic counselor who works with DTCGT clients. The counselor interviewed had three years of experience in counseling DTCGT and had prior experience working as a clinical genetic counselor. Her private practice is based in southern California. The interviews lasted from 20-67 minutes and have a mean of 37 minutes. The two clients who did not have whole exome sequencing performed had undergone SNP-based direct-to-consumer genetic testing from two distinct DTCGT companies. Those who underwent WES had testing done at the same DTCGT company.

Name	Gender	Age	Test Discussed	Genetic Counselor	Ethnicity (Self-Reported)	Highest Education	Occupation	State of Residence
Terry	M	63	WES	1	Western European	Masters	Retired Programmer	TX
Susan	F	61	SNP-based	2	Italian	Some College	Retired Bookkeeper	NJ
Mark	M	26	WES	1	Caucasian	Bachelors	Software Engineer	WA
Jannette	F	58	WES	1	Caucasian	Bachelors	Creative Director	CA
Robert	M	51	WES	1	Caucasian	MD	Anesthesiol-ogist	MD
Mary	F	56	WES	3	Caucasian	Bachelors	Aviation Safety Inspector	AZ
Anita	F	37	SNP-based	1	Ashkenazi Jewish and Hispanic	Bachelors	Job Developer	CA
Victoria	F	44	WES	1	Caucasian	Bachelors	Business Owner	TX

Table 1.1 Demographic and background information for the 8 clients who participated in genetic consultations.

Clients were purposively recruited based on 1) having received DTCGT results and participated in a genetic consultation within the past three years, 2) current residence in the United States of America, and 3) being an adult 18 years old or older. The genetic counselor with DTCGT counseling experience was purposively recruited for her experience providing consultations for consumers of DTCGT.

Clients were recruited via three genetic counselors who provide DTCGT counseling services. The counselors circulated an email announcement and information sheet about the study to former clients via email. Interested individuals contacted the researcher by

email between December 2019 and March 2020 about potential enrollment in the study and to confirm eligibility to participate. After eligibility criteria were confirmed, the researcher shared and reviewed the study information sheet as part of the consent process. The study information sheet provided details about the topic of research and the involvement of informants. Enrollment in the study entailed a one-time audio-recorded 30-60 minute interview to discuss consumer experiences with their DTCGT data. Interested parties were informed that no identifiers would be retained, and that participation could be withdrawn at any time.

This study was determined to fall under the exempt self-determination protocol for the University of California, Irvine internal review board, and therefore did not require a formal approval process prior to the start of the study. Documentation of this determination is available upon request.

2.2 Interview Guide

The interview guide (Appendix A) was developed with the intent to capture participants' experiences and expectations as they moved through their journey with their DTCGT data. Interview guide questions were open-ended and focused on eliciting how participants' experiences before the consultation shaped their expectations with questions like "What prompted you to send your sample in for genetic testing?" and "What about your results made you want to seek out more information?". To gain a more in-depth understanding of how participant expectations were met and what they gained from the interaction, they were asked "What sticks out in your mind most about the appointment?" and "How would you describe your comfort level with your results now?".

The interview guide for the genetic counselor (Appendix B) was developed to gain insight into how she prepares to see clients and conducts her sessions. Interview guide questions included "Walk me through what you do when you first receive a request for a genetic consultation. How do you try to get a sense of what clients want from the session?" and "What do you think makes a successful session?". Questions were also formulated to complement and add depth to the accounts given by the clients interviewed.

2.3 Data Analysis

Audio-recorded interviews were transcribed verbatim and personal identifiers were removed and replaced with pseudonyms. QDA Miner Lite software was used to conduct data analysis. Transcribed interviews were first read and re-read to become familiar with the data (i.e., data immersion). Memoing was also employed to capture initial reactions to the data and thoughts for further exploration. Inductive primary cycle coding was performed tagging segments of the data and labeling emergent codes. Data analysis during primary cycle coding involved initially describing "what" participants shared. Secondary data analysis subsequently involved grouping identified descriptive codes from primary level coding, which involved little interpretation, into higher-order themes. A codebook was developed to capture these higher order, interpretative themes that were grounded in the emergent descriptive codes with exemplary quotes from transcripts as evidence. The codebook organizes the different experiences of informants within the context of the testing experience trajectories taken with their DTCGT results and the impact the genetic consultation had on their understanding not only of their results but also of the testing process (see Appendix C). Throughout the analysis process, special attention was paid to

interviewees' descriptions of their expectations and how their expectations changed over time and after genetic counseling. Data were analyzed first within groups of clients who had been counseled by the same genetic counselor (3 genetic counselors counseled 8 clients) and then compared across client groups counseled by different genetic counselors. Data was also compared first within and then across groups for similar testing type (whole-exome sequencing vs. SNP-based testing) [Corbin, J.M. & Strauss, A., 1990]. Finally, data were analyzed for how they answer research questions [Morse, J.M., 1995; Urquhart, C., 2013].

Data from the interview with the genetic counselor was analyzed to take into consideration the genetic counselor's perspective and interpretation of clients' expectations or changes in expectations before and after the genetic consultation. Client descriptions of their experiences were compared and contrasted with that of the genetic counselor's description and interpretation of session discussions.

Findings

Descriptions of clients' testing and counseling experiences emerged as one of two types of experiences: 1) descriptions of motivations and expectations of DTCGT services and the genetic consultation 2) reflections about their experiences as a whole. Within these larger categories, five major themes emerged: seeking information, hopefulness, frustration, satisfaction, and questioning.

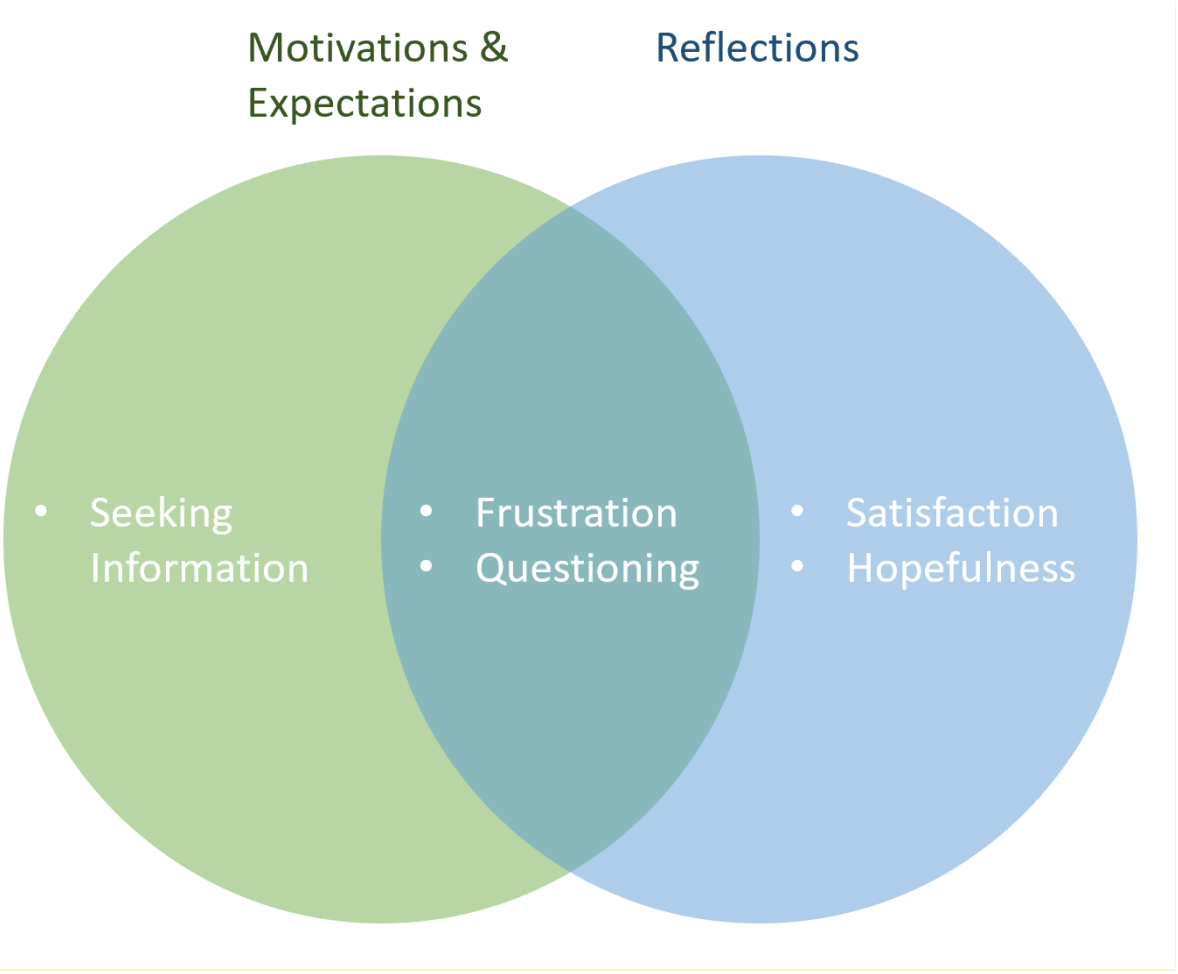

Figure 1.1 Graphic description of the interplay of themes throughout the DTCGT journey.

3.1 MOTIVATIONS AND EXPECTATIONS FOR DTCGT

When interviewees described why they chose to pursue DTCGT, a variety of motivations and expectations arose. Although most had a general desire for insight into their genetic information, some saw DTCGT as the only avenue through which they could obtain this information. Informants also described how they decided on which DTCGT company to use.

3.1.1 Desire for Personal Genetic Information

<u>Family History Health Concerns</u>

Informants described concerns about family health history that was both known and unknown. Robert described that he pursued DTCGT because:

> "There's a family history of aortic aneurysms on my mother's side of the family… [my dad has] had a couple cancers so I wanted to make sure there wasn't anything glaringly obvious in my genome that I should be concerned about." (Robert)

He was seeking information that might explain his family's history and help him better understand if he inherited specific genetic changes that were especially worrying. Anita's concern about her family history stemmed from the fact that:

> "I was raised by my mother and…was basically disconnected from my biological father for the majority of my life…so part of it is having this family history I'm not too educated on". (Anita)

As opposed to having an overtly concerning family history, she was hoping to expand her limited health knowledge on one side of her family. DTCGT was seen as a way to fill in that missing information so she could have a better picture of her family health history.

Wanting Answers for Personal Health Ailments

Clients sought answers for personal health concerns in two ways. One was to confirm genetic conditions that had been previously diagnosed:

> "I do have a genetic disease…and it was just intellectual curiosity to see if my test would show up that as a genetic condition." (Terry)

And the second was to seek a diagnosis for symptoms that they were currently experiencing. In Victoria's case, she "was really sick with autoimmune disease conditions and [my doctors] couldn't figure what was going on". In both instances, pursuing DTCGT was motivated by the anticipation of a specific piece of genetic information that would explain health manifestations that were either known or suspected to have a genetic etiology.

General Curiosity and Optimizing Personal Health

Informants also expressed a general underlying curiosity about their genetic information. Some commented that they sent samples to DTCGT companies because the tests were "like an old-time parlor game just to see what they turn up" (Terry) and to see if the tests and interpretations would confirm suspicions about health characteristics they may have contributed to genetics, such as a predisposition to cavities even though "I take exceptional care of my teeth. And that just doesn't make sense and so it's genetic!" (Victoria). Others were seeking insight into how to prevent future health complications or advice on how to live a healthier lifestyle.

Multifaceted Informational Motivations

Seven of the eight interviewees submitted samples to multiple DTCGT companies or input their raw data into one or more third-party interpretation websites. For example, Robert's motivation for pursuing whole-exome sequencing was to gain information related to his family history of health concerns. He later mentioned he had also submitted a SNP-based test to a different DTCGT company to trace his ancestry. Additionally, Susan submitted her sample for a SNP-based DTCGT to attempt to identify the molecular etiologies for her clinically diagnosed conditions. Yet, she also obtained her raw data and had it analyzed by a third-party interpretation site that could tell someone "like if you have- present with certain things...you might be more or less prone to- maybe you don't digest fats well or something like that". Thus, informants' motivations for pursuing DTCGT and their expectations of what the information could tell them were often numerous and varied instead of focused.

3.1.2 DTCGT Expectations

Some clients expected DTC genetic tests and third-party algorithms to tell them "nutritionally, you should be eating this and not that" (Jannette) while others expected more broad advice concerning how to "live like, a healthy life and do what I can to extend that as long as possible" (Anita) or provide concrete direction on "if there's something I can do to prevent something that might happen as I get older" (Susan). In line with the information-seeking motivations discussed above, informants also expected to learn more about "some things that I was specifically looking for" (Robert) based on a family history of

health concerns and more precise pieces information that would confirm what they already knew about their health or diagnose them with a genetic condition.

3.1.3 Privacy Concerns

Some informants voiced concern about the privacy of their genetic information before they submitted a sample to a DTCGT company. However, the whole-exome sequencing company that six of the informants used advertised a more robust privacy policy than others. Of those six informants, half cited the company's privacy policy as an additional motivation for deciding to pursue DTCGT:

> "I didn't want to do something like [this popular SNP-based test] at the time because they sell that information to big pharma. And so I wanted it to be private... I think that it is nice to have a company that will do it in a private manner, fashion so that you know your information just isn't out there" (Victoria)

> "I kind of liked the clinical trial story that they were telling and the fact that you continue to own your own data...I had heard that people could own your gene mutations somehow. That once they've studied it and they have it, that it could be theirs somehow. And that they could share it with people and I am very nervous about insurance...I'm nervous about and do not trust the insurance companies at all." (Jannette)

Both Victoria and Jannette expressed nervousness that they could lose control of their genetic information once they sent a sample out for testing. Some direct-to-consumer companies have earned a reputation for selling or giving out their customers' genetic information. There is also a distrust of corporations that could exploit people's genetic information, such as insurance and pharmaceutical companies. This hesitation also applied to third-party interpretation services. When Robert was asked if he had input his information to third-party services, he expressed:

> "I didn't and- there's some privacy concerns with it. I was happy with [the whole-exome company] because they said your data is your own, here it is. You know, you keep it, you can participate in research." (Robert)

As exemplified by Jannette and Robert, another draw of this particular whole-exome testing company was that it promised consumers they could still be included in genetic research, such as clinical trials. This sentiment was echoed by others who saw the test as a great way to contribute to genetic research without compromising the privacy of their genetic information.

3.1.4 Perceived Cost Barrier to Clinical Services

Some clients expressed frustration about being able to easily access clinical genetic testing and/or professional services. Some had an existing condition that they wanted to prove or disprove had a genetic etiology, but the cost of a clinical consult and genetic testing was a deterrent for them:

> "I do have- another thing that a doctor diagnosed like maybe 25 years ago, [condition name], and that's something else that I always really- no one ever sent me for a genetic test for that...But I didn't go to a genetic counselor or in for any genetic testing on my own because of the expense. So I wanted to go through a regular medical doctor. But they all seemed hesitant to do that." (Susan)

In addition to the barrier of cost, Susan did not feel like her pursuit of genetic testing was supported by her medical doctors. She assumed that testing could be ordered through a professional like a primary care physician and when that expectation was not met, she became frustrated and turned to the path of least resistance: DTCGT. Since she was already diagnosed with the condition, Susan was focused on getting her results. DTCGT presented itself as a cost-efficient way to procure the information she desired with no need for compliance from a healthcare provider. Similarly, Anita felt that DTCGT was the only way

she could access genetic services at an affordable cost. She was very interested in speaking with a genetic counselor but did not have a clinical indication to seek the service:

> "I assumed [genetic counseling] was very costly...I figured if you were interested in having any kind of insight into your genetics, the only way you could do it affordably would be if you had a medical reason. And I didn't. I was just curious." (Anita)

Although she hoped to speak to a genetic counselor, she also knew that her insurance would not cover the cost of her visit since she did not have a clinical indication to seek out these services. But her curiosity was still strong enough to justify paying for non-clinical services through DTCGT. Anita later noted that she uploaded her information to a popular third-party interpretation site because she "got a cheap rate". Another informant, Mark, bought many of his DTCGT packages during "a Black Friday sale". Shopping holidays in the United States such as "Black Friday" present opportunities for DTCGT companies to lower prices in order to attract customers. The low costs and lack of oversight needed to order the tests made them appealing options for consumers looking to gain access to their genetic information.

Although the cost of clinical testing and counseling was not a direct concern for Victoria, she mentioned that the cost of just the genetic consultation could be a barrier to accessing professional genetics services for some:

> "It's a highly specialized field with what you guys do. And you know there's a price that comes with that...I know that there are a lot of people in this country who cannot afford to do that and so that makes it hard. Because you want- you want to pay your people accordingly because they're very educated. Highly educated. But at the same time you do want it to be accessible to more people." (Victoria)

She qualified her statement by acknowledging the expertise of genetics professionals who work with this information but voiced an underlying concern that only those who can afford the cost of speaking to a professional will have the opportunity to explore their data.

3.2 MOTIVATIONS AND EXPECTATIONS FOR GENETIC CONSULTATION

These informants who sought genetic consultation carried many of their motivations and expectations from their DTCGT or third-party interpretation results over to the sessions with the genetic counselor. However, their motivations and expectations evolved from general interests or expectations concerning their genetic information to specific inquiries or lingering questions. Clients had reacted to their results and became more interested in the information from their reports that they could not understand.

3.2.1 Validation of Personal DTCGT Interpretations

Some informants merely wanted an expert to take a second look at their results to ensure they were understanding everything they could from the data. Mary had spent five months looking over her whole exome sequencing data before she decided to schedule a genetic consultation:

> "Even though the [whole exome sequencing] company provided so much information, I really- it was all self-taught through [their] website. And I think one of the main reasons why I did contact the genetic counselor is because I wanted validation that what I had interpreted was correct." (Mary)

Although Mary felt the DTCGT company gave her good resources to research and evaluate her results, she also recognized her lack of formal education in the subject area. She sought the opinion of the genetic counselor in hopes that her interpretation of her data was correct, but more than that, because she expected the counselor to give her the most valid interpretation. Jannette expressed similar sentiments and actually worked to understand her data for a couple years before feeling confident enough to engage in an "intelligent conversation" with the counselor. However, confirmation was not sought only after long

periods of research. Robert "scheduled [the genetic consultation] out when I looked through the results because I was going to follow up with it regardless, even if I felt like my results were pretty normal...So within a couple weeks, I think we talked about it". He did not feel the need to conduct copious amounts of research on his own because "one of the things I've learned along the way is not to try and do someone else's job when they have a job that they do better".

3.2.2 Unanticipated DTCGT Results

Two clients also received results that showed increased risks in areas of their health they were not expecting. These unexpected results then motivated them to speak to a genetic counselor:

> "When I started looking through everything, you know you look for the risk factors for diseases and disorders so that was alarming to see. But I knew I wasn't understanding the whole picture so...I think I reached out to [the genetic counselor] like right away. Within 24 hours. And we probably set up an appointment in like a week." (Anita)

One interviewee, Anita, was taken aback by the results of her test. The initial shock of possible increased risks for health concerns drove her to schedule the consultation quickly in order to gain more clarity. While Anita had a profound urgency to consult with a genetic counselor, the other informant who received an unexpected result concerning her memory took five months to research on her own before seeking genetic counseling. She explained that she needed the five months to prepare herself for the conversation. In contrast, Robert, whose test returned no striking findings, scheduled his genetic consultation immediately after receiving his results because he valued the confirmation and closure that meeting with a specialist would provide.

3.2.3 Confused and Overwhelmed by DTCGT Results

Others were confused and overwhelmed with the sheer amount of data they received from the DTCGT company or the third-party interpretation service. Even though each informant had specific topics they were interested in, they had either tried to make sense of the information and became overwhelmed or went straight to a genetic counselor who had experience interpreting the data:

> "So I have all this extant information but I don't have the background and education to make use of it so that's probably what was the driver for me to finally say-oh and it wasn't much maybe [a certain amount] I don't remember exactly for this analysis." (Terry)

Terry was also an especially motivated individual who seems to have a fascination with the study of genetics. He had even joined online forums to try to understand his data better. However, he noted that there was a point where he recognized that properly analyzing his data would "[take] some serious study that [he's] not willing to put in." Similarly, even when informants tried to sort through their data on their own, typically after receiving results from third-party interpretation sites, they would become confused because "sometimes you're looking at one thing and it seems positive but sometimes you look at something else and...you need someone to help interpret these for you." (Susan).

3.2.4 Expectations for Consultation

The genetic counselor was expected to be an authority on genetics who could provide consumers with more insights into their genetic information based on their DTCGT results. Some were "interested in [exploring] the subtleties that maybe I wasn't- that I hadn't appreciated" (Robert) and expected the genetic counselor to guide them towards a

deeper understanding of what the data means. Others expected the counselor to "break it down and explain it to me a little bit more" (Anita) so that they could analyze their data with the proper background information in mind.

Meeting with a genetic counselor for a consultation was also a way for these consumers to ask more specific questions pertaining to what they had already found in their data. Interviewees expected the counselor to go through the data and "look at [the data] or at the very least answer some questions I had" (Susan) or "walk through the categorized as pathogenic variants" (Mark). As the professionals in this subject matter, it was also expected that counselors "could confirm that what I've learned on my own is true" (Mary)

3.2.5 Genetic Counselor Perspective about Client Expectations

From the genetic counselor's perspective, learning about client motivations and expectations before the session helps her for counseling sessions. Contracting begins with the first interaction between the counselor and client:

> "I will always…ask a few questions via email ahead of time just to kind of be able to understand and frame what it is that they're trying to achieve with the consultation. And also kind of where they're at psychosocially as well." (GC 1)

This pre-session assessment through email allows the genetic counselor to gauge client expectations and prepare accordingly. She may also be able to identify what psychosocial concerns may have to be addressed based on the expectations she feels a client is putting on a session. When describing a patient population with nonspecific but systematic health symptoms, she observes:

> "They want to be able to look through in data and see look I have all these genes or I have this whole group of genes or I have this one gene that isn't working so see, this

> is proof. This is proof that I'm sick…when I hear that as an inquiry, I sort of definitely have to put on my psychosocial hat because I know that there's probably not going to be a smoking gun in their data. I know there isn't." (GC 1)

Through learning about a clients' motivations, she can begin to predict what they will expect from the session. Then, if she knows these expectations will be violated, she can be better prepared to discuss that with the client.

Regardless of the clients' concerns and motivations for seeking a genetic consultation, the genetic counselor described how she would begin to reshape expectations in the beginning of the session:

> "So [the consultation] is a lot of times the first time someone has learned that 'Oh! This isn't my genome. This is just a few hundred thousand data points within my genome, this isn't actually my whole genome.' So once I kind of explain what a variant is, I'll say you know we're actually only looking at a very small subset of your variants and within those we're looking at ones that may not actually be accurate as variants. And even if they are accurate, you don't always actually really know what they mean. So I kind of do it as a big picture, zooming down into the details." (GC 1)

Through clarifying the nature of clients' results, they can begin to get a better idea of what their data is representing. The genetic counselor mentioned that even through this initial information spiel, clients are usually exposed to new information. This unexpected event in the beginning of the session may make the client more amenable to unmet expectations as the two continue to talk.

When the genetic counselor was asked what a successful session looks like, she described her belief that, regardless of the expectation:

> "A successful session isn't one where people leave necessarily happy but I think a successful session is one where people leave the session feeling empowered and educated and are capable of critically thinking about their data in a way that they were not able to before" (GC 1)

The largest emphasis is placed on the clients' ability to think independently after the session. Whether the genetic consultation centers around a small misconception about

genetics or requires a deep dive into specific variants, she hopes that in the end the client can walk away with a more comprehensive and accurate understanding of what their information is communicating. The end goal of these sessions is to equip clients with information and support so they can be more confident in their ability to look through their information with a critical eye.

3.3 CLIENT EXPERIENCES FROM THE GENETIC CONSULTATION

All clients interviewed reported that they did not regret their decision to pursue a genetic consultation for their DTCGT data. Most learned something new about genetics and had positive feedback for the counselor who conducted the session. Informants often did not receive the types of answers they were hoping for but nonetheless left sessions feeling like the information they did learn contributed to their journey with their DTCGT data. Expectations for information were not well met during the consultation but clients perceived most as positively violated.

3.3.1 Positive Takeaways

<u>Receiving Personal Trait Information</u>

Informants enjoyed receiving DTCGT results that spoke to personal traits they observed in themselves. Even though this information was not specific to their motivation for pursuing testing, it provided some entertainment. For example, informants mentioned receiving results like having a "gene for empathy" (Anita) or having their data suggest they are better at running long distances when they used to run marathons in their youth. Robert noted it has been "fascinating" to look back at his family history and that "my

daughters have kind of enjoyed me digging back into the background and tracing things back to various snippets of history". Those who mentioned this type of information in their interviews also described it as "a great deal of intellectual fun" (Terry) or "fun stuff, little bonuses" (Anita). Interestingly, the three respondents who commented on these infotainment results had purchased tests from multiple DTCGT companies or input their data into multiple third-party interpretation sites.

Personalization of Session

Informants described how the genetic counselor was able to personalize their session:

> "She took the time before we had the session to ask me about my background. So like my educational background and my interests and so, it was nice because like I said I do read these blogs and listen to these podcasts so there's some terms that I'm familiar with, right? And so we're able to have a better conversation because of that and I really appreciate that. So I hope a lot of professionals are doing something like that." (Anita)

Anita and others expressed that the contracting phase of the session left a lasting impact on the way they remember the genetic consultation and the genetic counselor. The interview with the genetic counselor revealed that she will purposefully ask:

> "What they do for a living, if they have a background in the medical field or in genetics or in data analysis...I also try to get from them sort of in the beginning of the conversation how they've been thinking about and approaching their own data because so many of them have spent a lot of time on the data already before they even come to me." (GC 1)

This purposeful consideration of the client's background greatly aided in the perception of the session as more of a conversation. It was common to hear the appointment referred to as a conversation because the counselor had laid the groundwork so both parties could talk at the same level. This is also a testament to the space the counselor was able to facilitate.

Not only could the counselor convey information in ways that made sense to her clientele, she was also able to make people feel secure enough to engage in an active dialogue. Ultimately, this approach allows for a more free-flowing session, which benefits both the counselor conveying the information and the client receiving the information.

3.3.2 Feelings of Relief and Reassurance

For clients who sought confirmation of their research or wanted the counselor to provide more context for their results, their expectations of validation were met. This satisfaction of met expectations instilled feelings of relief and reassurance:

> "I think if I hadn't done it I would have always had that little thud in my head, you know I hope I didn't miss anything, I hope I didn't miss anything. And she looked at all the same information and came kind of to the same conclusions. I felt much more relieved…So she really helped me a lot. Settled my mind." (Mary)

> "I spoke to my father just to let him know 'Hey the genome looks great. There's nothing in there that's super bad.' You know so that- I think as a parent and a grandparent that's always something good to hear. That there's not nothing in there that's terribly concerning that you've left for the next generation." (Robert)

The consultation provided these informants with great peace of mind. After meeting with the genetic counselor, neither expressed residual concerns that information in their results might have been overlooked or were not fully explained. Mary and Robert received confirmation that their self-researched conclusions concerning their data, which lacked major abnormal findings, were correct. This had implications for both their own health and that of their families. These strong feelings also reflect their perceptions of the validity of DTCGT data. If they did not believe the data was at least reasonably accurate, they would not attribute as much weight as they do to the lack of findings. As part of the consultation, the genetic counselor who was interviewed describes the limitations of the testing.

Although she reported that the DTC whole-exome sequencing company provides more accurate data than the SNP-based tests, results from neither type of tests can be used in clinical practice without validation through a clinical laboratory. Overall, it seems these informants are more prone to remember the feelings of relief and reassurance that the information gives them instead of its limitations.

3.3.3 Perception of Met and Unmet Expectations

Positive Unmet Expectations

Even when initial expectations for the session were not met, clients maintained that they were satisfied with the information that the genetic counselor was able to provide. Victoria came to the genetic counselor with a specific goal in mind. She was immediately overwhelmed by the data and was mainly seeking clarity concerning her undiagnosed autoimmune symptoms. However, the consultation propelled her in a completely different direction with her data:

> "I think because when I spoke with the counselor and she said that about 'Oh, do you have drop-foot? Do you have an issue with your leg?' And because my son did, it really made me dive into the data and the information more than I probably would have because...it gave me some hope for an answer with him." (Victoria)

She came into the session with hopes that the information could shed light on her own health, but left with more hope for her son. While it was not the type of information she expected to walk out of the session with, it was received positively and gave her more direction than she had before meeting with the counselor. Victoria later expressed that the session was not very helpful for her own health and that the DTCGT data itself is still very overwhelming. But throughout the interview she repeatedly stated that the genetic consultation served as her pivot from focusing on herself to finding an answer for her son.

This redirection of focus depicts a violated expectation that was received positively because the unexpected information incentivized her to continue her journey with her genetic information and resulted in a positive perception of the genetic consultation. Interestingly, Victoria also mentioned "I'm still glad I did [the whole-exome sequencing] because it's all in what you know", implying that the information itself, even if it cannot be understood, has intrinsic value.

Clients approached their genetic consultation with certain expectations about the information they would learn and the discussion they would have with the genetic counselor. Anita expected the counselor to go over her points of concern and provide advice based on those findings but:

> "What happened [in the session] like exceeded my expectations. Like I didn't even have the expectations for what we ended up doing which was way more helpful than what I initially wanted from it" (Anita)

She was hoping to gain insight into specific parts of genetic information, but the genetic counselor took the analysis a step further by backing up to review what the information as a whole could and could not reveal. Anita was not expecting to receive information that went beyond the points she hoped to bring up with the counselor but was pleasantly surprised when the counselor took the approach of understanding the data as a whole in order to give context to the specific concerning findings. Ultimately, Anita got more out of the session than she was anticipating and came away from the session with a broader understanding than she was hoping to gain.

Negative Met Expectations

Results were underwhelming for some. Unmet expectations were not always met with enthusiasm. Mark sought a genetic consultation to learn more about the pathogenic variants reported by third-party services. He expressed that:

> "[The genetic consultation] provided me some useful pointers...I don't think it was life-changing information that-had I known what it was going to be after the fact I may not have wanted to pay [the amount of money for the consult] for it but it was not, not worth [that amount of money]." (Mark)

Mark's curiosity was satisfied in that he received the information he hoped to learn about, but that information was more underwhelming than he had anticipated. Although he later commented that the genetic consultation helped prepare him to conduct more independent research, he perceived the experience as "interesting but not super useful I guess because I don't really have any terrible genetic diseases". The outcome of the consultation fell flat for Mark because he expected to be given more significant information than he received. Nonetheless, at the end of the interview he expressed that the consultation was, for the most part, worth the money he paid.

3.3.4 Realization that Genetic Information is not "Black and White"

Even with their enthusiasm surrounding genetic testing, consumers made statements that illustrated their capacity to think critically about their DTCGT data. Anita, who would share her third-party interpretation results at parties, also reflected:

> "If I look at just my family history well a lot of people in my family have that history. So it's like, did I need the genetic test to tell me that or could I just have looked at my history?" (Anita)

Victoria also commented on how her perception of genetics as a whole has changed:

> "Genetics is so fascinating to be but it's just so strange. It's not so black and white which I think is hard for a patient to understand but now with the whole journey, I get it". (Victoria)

Both still believed having access to their genetic information was a great opportunity, but their expectations concerning what it can deliver had been dampened. Or, maybe more accurately, they became more realistic, given the scientific community's current understanding of this complex information.

3.3.5 Frustration with Current Genetics Knowledge

Informants expressed frustration at the realization that genetic research is not as advanced as they may have anticipated:

> "I was a little disappointed that we were not further along...basically, a lot of the mutations are kind of guesses. And that's kind of- I was kind of like *slap table* really, we're not further along?" (Jannette)

Jannette, initially sought concrete information from her DTCGT data and hoped the results would help her optimize her health by suggesting dietary changes and guiding proactive health management. She, and others with similar motivations, expressed that their "[the consultation] was a big relief, really…I feel like I've done as much as I can so I can feel good that I'm being as proactive as I can be". Although the frustration with the current understanding of genetics is evident, this does not seem to affect the perception of the consultation. Even though it seems like this violation of the expectation for specific information would have an overall negative effect, clients were still appreciative of the session and felt like they were given enough to feel satisfied with the consultation as a whole.

This frustration with the information currently available is also felt by the genetic counselor. Despite this, she tries to encourage her clients that their curiosity and excitement is a good thing. During the interview, she emphasized that:

> "I'm very excited for them and feel…happy that this is something that's emerging. It's just the expectations about it just probably need to be a little bit lower. For now. There's only room for growth, knowledge is exponential...I think there's something very exciting about that so I always try to put in that positivity to the conversation regardless of motivation." (GC 1)

Although the genetic counselor aims to foster the initial interest in clients' genetic information that motivated them to do testing, she is also impacted by these high expectations placed on genetic information:

> "To ultimately have to tell these people that you're working with poor data in a poor bioinformatics environment with the potential for a lot of inaccuracies and even if there was something in here that was compelling I can't trust it. That's a frustrating situation for the counselor and for the client. Because here it's basically like oh here you've already spent all this money on all this testing and now I have to tell you that it is kind of not particularly useful." (GC 1)

The genetic counselor commented that she often has to play the role of the "bubble burster" (GC 1). In addition, genetic counselors in private practice do not typically have opportunities for follow up with their clients. Although some clients may express gratitude towards the end of the session, they ultimately go "off into the ether" and the counselor is left wondering how the clients processed the information and made use of it.

3.4 CLIENT OUTLOOKS POST-GENETIC CONSULTATION

For many, this journey has not yet provided them the answers they initially sought. Yet, they remain optimistic about the information that will be uncovered and the medical advancements still to come. After meeting with the genetic counselor, informants

expressed better understandings of their DTCGT information some doubts about the process of DTCGT.

3.4.1 Hopefulness for the Future of Genetics

Informants displayed a fascination and excitement for DTCGT that translated to hope for the advancement of genetics. This was especially noticeable when they talked about their desire to contribute to genetic research and about the impact genetics will have on the future of healthcare:

> "And [my information] is still out there and it's continuing to evolve...it also gives me a lot of peace of mind to know that...people continue to research on it...So you know, it's what you do as a scientist and physician. You want to get information out there that can improve the field and make things better." (Robert)

> "Imagine being able to eliminate malaria around the world. That would be a greater thing than eliminating smallpox. Imagine being able to make sure genetic diseases are eradicated before birth or that people's genomes are changed so that they, the recessive traits aren't passed on and imagine how great that is." (Terry)

In general, informants held optimistic outlooks about how the field of genetics will advance. Robert communicated his commitment as a physician and as someone who has done DTCGT to contribute to the larger dataset of genetic information available to researchers. Although he was the only physician in this cohort, his sentiment is one shared among informants in this study. His statement also highlights the willingness to share genetic information if it will be used for the greater good of research. Terry conveyed a very broad and far-reaching perspective concerning the future of genetics. His sentiments concerning the eradication of genetic conditions do not align with those held by genetics clinicians and researchers, but his expression does highlight his hope that the field will continue to grow and advance. Others also discussed their hope for more personalized

treatments and health advice. Susan is very excited about the future of precision medicine because "when they do these major studies on drugs or diet they take a cross-section of people but they- each person might react differently to something. So I just feel like it's sort of like a safer bet to go through your genes." And so, genetics is portrayed as a great frontier that holds vast potential for people on an individual level, but also for humanity as a whole.

3.4.2 Empowerment to Seek More Information

Informants could recall specific information from the genetic consultation surrounding what they perceived to be key information and useful points. Of course, it is unknown to what extent their memories accurately reflect what the genetic counselor meant to communicate. But informants displayed recall of information that would help them if they decided to reanalyze their data or, in the case of third-party interpretation services, input new data to analyze:

> "She explained how I should click a certain button and reorder my information so it's by rarity and she focused on the rarest of the mutations and looked at those and see this one, this one, and this one are the ones to sort of keep an eye on. We don't really know that much about them. And then there's these others ones that while they say they're pathologic that's unrealistic because it presents in 30-40% of the population so we know it can't be that bad. So that context was helpful" (Jannette)

Clients like Jannette felt much better equipped to process their information after meeting with the genetic counselor. Not only did they feel more comfortable with their current results, but they also took away knowledge that could help them as they continued their journey to discover more about their genetic information.

After the consultation, informants also continued to seek more insights from their genetic information. This took the form of pursuing additional genetic tests, both clinical and DTC, and entering their raw data into other third-party interpretation sites. Anita later entered her data into a more nutrition-based third party site she found off of a nutritionist's blog. She found it "easier for [her] to read that [report] and understand it and not freak out about certain things that came up". From the genetic consultation, Anita was more empowered to engage further with her raw data because she felt more well-equipped to interpret the outputs. This better understanding propelled her journey forward and has made her feel like a more informed consumer. Comparatively, Susan described that she sent a sample to another DTCGT company but is also interested in pursuing clinical testing if she can "find a doctor that will do that for [her] because looking at [her] raw data there wasn't any variation on...it's totally inconclusive, [she'd] like to find out more about [her condition]." The genetic counselor was able to confirm that Susan's data did not identify variants to support her clinical diagnoses. However, while other informants perceived the absence of significant abnormalities and confirmation of their research positively, this lack of findings did not resolve her initial motivations. Although her expectations of the information DTCGT could provide were not well met, this actually made Susan more willing to pursue clinical genetic testing which is more suited to establishing a molecular diagnosis for a genetic condition.

3.4.3 Frustration Concerning DTCGT Information

Informants expressed frustration with the process of interpreting their DTCGT data. Terry called for not only "an independent body that would judge the quality of these [third-

party] services", but also a way for him to personally look through a list and select the genetic counselor who he would see for his consultation. His suggestions for improvement emphasize the lack of regulation in the third-party service space and the limited number of professionals purposefully engaging with this type of genetic data. Jannette was interested in taking research into the consumers' hands by creating "a platform where we could share all our data and have a collective so that we input data about, like I found dietary things that work for me and that correlated with other people with this sort or group of genes". Their ideas, although practical from a consumer standpoint, likely have limited utility to clinical providers. However, these thoughts for improvement further highlight informants' desire for a better understanding of their genetic information and a strong belief in the future of genetic research.

3.4.4 Skepticism of the Validity of DTCGT Data

Mark voiced that he had doubts about the accuracy of his DTCGT data. After the genetic consultation, he continued to pay for additional DTCGT and analyzed multiple sets of raw data from different DTCGT companies using the same third-party interpretation site. From this, he noted:

> "That always leaves me confused because I have- there's not as much overlap as I would have hoped for between the three samples that I have...you'd expect [the same SNPs] to show up with the same result on all three of the services at least 90% of the time?" (Mark)

Through his pursuit for more information, Mark uncovered discrepancies between his DTC tests. Unintentionally, his lingering curiosity led him to conduct an experiment and, in a way, disprove his null hypothesis. Mark's is a unique case, but it does highlight the drive informants have to learn more from and make sense of their genetic information.

3.4.5 Lingering Concerns About Privacy

The privacy concerns posed by informants as part of their motivation for pursuing DTCGT data did not seem to be addressed in the genetic consultations. During their interviews Robert and Terry inquired about the safety of their genetic information even in a clinical setting where Health Insurance Portability and Accountability Act (HIPAA) policies [Annas, G., 2003] are enforced:

> "How do you address people's privacy concerns about [genetic information]? (Robert)

> "Do they have to follow HIPAA constraints? Does my DNA come under HIPAA constraints when I'm getting medical advice? I don't know if society has caught up with those aspects yet." (Terry)

Although the nature of both inquiries seemed to be more out of curiosity, there was a general lack of knowledge about whether genetic information fell under the protections for patient confidentiality that are part of HIPAA. In the general population, this finding would not be surprising. But it was surprising that these two, an anesthesiologist and a consumer who had done as many as ten DTC genetic tests, had not considered this aspect of discussing their genetic information with a professional earlier. Even more curious is the above statement by Terry in contrast to a view he expressed earlier in the interview:

> "I do not keep my information private. I make it all public...I may be another Helen [*sic*] Lacks and have something really great in my genome but I don't have the finances nor the education to make use of it for the better good for society. So if someone else can do that I'm happy for them to take it and make money off of it...I think everyone else walks around like there's a gold mine in their- in the middle of their nucleus cells but they have no way of accessing it so it's of no value. But wouldn't it be cool if I had some contribution." (Terry)

So although he was interested in learning more about the privacy protections in place for genetic information being reviewed in a clinical context, the same curiosity does not apply

if his information is being accessed for the purposes of research and discovery. In fact, he is more than willing to have researchers make use of his information, possibly even without his consent, if it can be used for a greater good.

Discussion

Through these nine semi-structured interviews, five major themes emerged to describe how informants have interacted with and perceive their DTCGT data: Seeking information, hopefulness, frustration, satisfaction, and questioning. These themes also lend themselves to illuminating how the expectations held by clients have evolved and continue to be shaped. The motivations for DTCGT testing and perceptions of what this information could deliver greatly shaped the expectations of the tests themselves and of the genetic consultations. After meeting with a genetic counselor, informants expressed greater understanding of their results but held onto the hope that their genetic information could one day be used to meet their initial expectations.

4.1 KEY FINDINGS

4.1.1 Motivations and Expectations

DTCGT and 3rd-party Interpretation Services

Although this study focused on eliciting the expectations of clients, their motivations were closely tied to their expectations of DTCGT results and the genetic consultation. Informants were first motivated to seek out DTCGT to gain insights into their genetic information, a source of health information that consumers did not have access to until the early 2000s. Consumers expected concrete information that would inform them of their personal health risks in relation to their family history and current ailments, ways to better their lives, and information that would sate their underlying curiosity about their genetics. Expectations also ranged from specific concerns, such as personal health concerns, to a general sense of wanting information to better themselves. Informants did not always

know exactly what they were looking for when beginning their journey with DTCGT but were intrigued by the opportunity to learn more from this novel information source.

Even before deciding to pursue DTCGT, some informants expressed concerns about the privacy of their genetic information. This desire to maintain their privacy motivated informants to submit their sample to the whole-exome sequencing DTC company who advertised that their customers can maintain control of their information while still being able to participate in research such as clinical trials. In employing this marketing tactic, the whole-exome DTC company highlights the pervasive concerns surrounding privacy in the DTCGT industry. Furthermore, the decision of informants to submit to this company over others indicates that the strategy is effective at addressing a need in their target population and is, therefore, an important consideration for those seeking DTCGT.

Frustration with obtaining clinical genetic services was also a motivator to seek out consumer-initiated genetics services. In pursuing DTCGT, informants described stories of clinician reluctance and expense barriers that made DTCGT a more appealing alternative.

Genetic Consultation

Informants expressed frustration with their DTCGT results when the information did not offer the answers they had hoped. This led to feelings of confusion and caused informants to become overwhelmed. Others sought validation of their personal analyses or to make sense of unanticipated DTCGT findings. Given these motivations for seeking genetic consultation, the genetic counselor was accurately seen as a professional with specialized knowledge who could help provide guidance and clarity for DTCGT results. Informants carried their expectations of concrete information over to the genetic

consultations. However, they also came into sessions with their DTCGT results and the independent research they conducted. So although their expectations were generally more specific to DTCGT findings, informants were still focused on obtaining information that provided answers to their concerns.

Informants chose to seek out genetic counseling at different times in their journey with their DTCGT data. While some felt an urgent need to consult with a professional concerning their DTCGT information, other took more time to research or understand their results. In one case, an informant looked over her data for a couple of years before seeking a genetic consultation. In contrast, another informant scheduled an appointment within weeks of receiving their results.

4.1.2 Experiences from Genetic Consultations

When informants were asked to reflect on their journey with their DTCGT data, varying levels of satisfaction and hopefulness were expressed. Those who were seeking confirmation or context for their results were most satisfied with the guidance provided by the genetic counselor. Many also expressed appreciation of the time the genetic counselor took to personalize the session for them, a contrast to the digital landscape encountered when interacting with DTCGT websites and third-party interpretation services. Informants gained satisfaction from receiving "info-tainment" such as predictions that they are better at running long distances. This may have satisfied expectations of receiving concrete information, even though it was not health-related, or could have merely served as entertainment that informants thought was intriguing enough to mention in the interviews.

Although many informants did not receive the concrete information and advice they were seeking, none expressed that they regretted meeting with the counselor. Even those who were underwhelmed with the results reported finding some type of value in the consultation. Positive expectation violations were perceived when the genetic counselor went beyond the scope informants were anticipating and when the genetic counselor's interpretation gave new meaning to DTCGT results.

The consultations also provided clients with a new perspective. Many were surprised and frustrated when they realized that current genetic knowledge is not where they anticipated it to be. Although the genetic counselor expressed her own frustrations of having to explain the current limitations of genetic knowledge, she does try to instill hope that the answers her clients are seeking will be available one day.

4.1.3 Outlooks Following Genetic Consultation

Positive perceptions of the genetic consultation did not signal the conclusion of informants' journeys with their DTCGT data. Informants expressed a strong interest in contributing to research in hopes that they could help advance the body of genetic knowledge. Additionally, many later pursued additional DTCGT tests or input their data into additional third-party websites. With further testing, some informants became more skeptical of their DTCGT results or questioned their validity, while others were happy and content to have the information at hand. For one informant, interaction with their DTCGT data actually caused them to reconsider pursuing clinical genetics services despite the associated complications that led them to pursue DTCGT as a substitution.

Concerns about the privacy of clients' genetic information prevailed as some informants voiced questions to the researcher regarding how their genetic information is protected. Informants may have felt that conversations surrounding privacy were not needed because they had pursued DTCGT through the whole-exome company that offered to keep their data private. But these concerns posed to the researcher suggests that genetic privacy is a lingering concern among clients. Some also reiterated that DTCGT information is sold to third-parties. However, an opposing view also arose that argued in favor of open access to genetic information if it can be used to provide a greater good to society.

4.2 CONNECTIONS TO EXISTING LITERATURE

4.2.1 Motivations and Expectations

The motivations and expectations of consumers in the DTCGT space are well documented in previous research studies. One study that included healthy participants who underwent whole-exome and whole-genome sequencing reported that their motivations for pursuing testing included obtaining personal disease risk information, satisfying curiosity, contributing to research, self-exploration, and interest in ancestry [Sanderson et al., 2016]. This lines up well with the motivations reported in this cohort for pursuing DTCGT.

Schaper and Schicktanz (2018) propose that these underlying motivations of health-seeking behaviors when pursuing DTCGT may be promoted by the advertisement campaigns of the DTCGT companies themselves. These two authors document the utilization of empowerment in DTCGT company advertisements. The concept of empowerment serves a twofold purpose: it allows consumers to believe they are 1) taking

control of their circumstances (i.e. accessing information without the oversight of a healthcare professional) and 2) gaining information that can impact their present health decisions and therefore improve their future health outcomes [Schaper, M. & Schicktanz, S., 2018]. This study also touches on people's reliance on genetic determinism or genetic essentialism. In this mindset, genes are perceived as immutable placeholders that are used to explain how observed occurrences come into being [Heine et al., 2017]. Individuals who take this approach can then attribute the presence of complex diseases, or even characteristics such as a propensity to cavities, solely on changes in their genes. Given the presumed cause and effect relationship between genes and precise phenotypes, one could then make the conclusion that if they have knowledge of their genetic information, they would be able to prepare for the future of their health. By promoting the mindset of genetic essentialism, these websites are not only encouraging the notion that their tests can predict the health concerns one will experience in the future, but also the false hope that consumers can take definitive action in the present to avoid these health concerns before they manifest. Informants in this study were very much led to believe that their DTCGT results could assist them in proactively caring for their health. Exactly how these inferences were formed were not fully explored in this study but the advertising of DTCGT companies may have played a role. Schaper and Schicktanz (2018) also notes that DTCGT websites may also use imagery that implies a doctor or health care professional is involved in the process of ordering or interpreting testing [Schaper, M. & Schicktanz, S., 2018]. Although not noted in this cohort to consciously influence decisions to pursue DTCGT, this can be seen as an influencing factor presented to consumers to convince them of the validity of their product. Given these messages spread by DTCGT companies, it is not surprising that

consumers who experienced barriers to accessing clinical genetics services turned to these companies to provide them with the information they desired.

When motivations and expectations are examined together, it seems clear that informants sought high usability from their DTCGT results and the genetic consultation. This usability does not specifically pertain to clinical utility, a measure of how likely a test and its results are to improve patient outcomes, but does encompass personal utility in which informants could use this information to guide "decisions, actions or self-understanding which are personal in nature" [Bunnik et al., 2014]. This definition proposes that the data returned must first be interpretable and second serve a distinct purpose. Although some informants expressed a general curiosity, which in and of itself does not meet the criterion of serving a distinct purpose, their curiosity was more of an underlying motivation than a driving motivation or an expectation. Clients seem to have been under the impression that their results hold clinical utility, but practically these results, at best, hold personal utility. This is not emphasized to mitigate the importance of personal utility, but to instead stress the misconception surrounding the applicability of DTCGT results.

Although clients did not receive the type of information they were hoping to uncover through their consultations, this expectation violation was received positively as informants expressed satisfaction with the session. Given the genetic counselor's account of how she begins a session, it seems she tries to reframe and reset expectations in the very beginning. This strategy, along with her encouragement about the growth of genetic knowledge, appears to help clients understand why their expectations cannot currently be met. Additionally, her discussion provides them with hope that the information they

originally sought may arise in the future and validates their enthusiasm and excitement for genetics.

4.2.2 Access to Clinical Genetics Services

It was not surprising to hear that some informants encountered obstacles in obtaining or merely seeking out clinical genetics services. Informants cited the cost of the testing as well as physician reluctance to order genetic testing as barriers to seeking out clinical genetic testing and genetic services. The above is part of a larger discussion concerning the rapid expansion of interest in genetic services against the backdrop of physicians who are often unprepared to fully address patient concerns about genetics and a scarcity of healthcare professionals specifically trained in genetics. Although willing to integrate discussions of genetics into their practice, primary care physicians reported they felt ill-prepared to address such topics with patients despite their growing awareness of its importance [Harding et al., 2019b]. The sparsity of genetics professionals also impacts patients' access to these specialized and in-demand services. Current trends show a rising demand for genetics providers [U.S. Department of Labor, Bureau of Labor Statistics, 2017]. Even though the number of training programs in genetic counseling is expanding, the pool of clinicians can only grow so quickly. Clinics requiring a geneticist are often booked far in advance, making it difficult for patients with referrals of lower clinical concern to be seen in a timely manner. Additionally, those who are able to meet with genetic specialists can face steep costs associated with the clinic visit and the clinical genetic testing that may be ordered. In the United States, there is much ambiguity and inconsistency surrounding how genetic services and tests are processed by different insurance companies. Even patients

with clinical diagnoses of genetic syndromes can encounter barriers when seeking molecular diagnoses or specific treatments for their condition [Addie et al., 2018].

In contrast to the landscape of clinical genetics, DTCGT is much more accessible to those seeking to learn from their genetic information. As stated by informants, the low cost of DTCGT is a significant draw for many and the marketing tactics of the companies, as mentioned previously, can be very enticing to potential consumers who already have an interest in genetics.

4.2.3 Privacy

The general wariness of informants concerning the privacy of their genetic information is shared by others who have considered submitting samples to DTCGT companies [Schaper et al., 2019]. However, consumers are also eager to engage in research and some reported they would willingly sacrifice the privacy of their genetic information if it meant advancing the knowledge of society or contributing to the greater good [Haeusermann et al., 2017]. Robert and Terry are also not alone in having questions pertaining to their privacy. Of ten informants who participated in a study about the privacy of their DTCGT information, only five believed there was a law that protected their genetic information, and only one of those five specifically mentioned the Genetic Information Non-Discrimination Act (GINA) [King, J., 2019]. Although these informants did not meet with a genetic counselor, they expressed similar motivations for pursuing DTCGT and attitudes towards sharing data in order to advance the current understanding surrounding genetics.

Client concerns about the privacy of their genetic information are also warranted given a number of technical studies recently conducted on publicly available genetic databases. A recent study has established that hackers accessing a third-party genealogy

database using a falsified file of genetic data can extract up to 98% of other users' uploaded data with 92% accuracy [Ney et al., 2019]. Because this is a third-party service that accepts a number of file formats from numerous DTCGT companies, the researchers could also gain access to medically sensitive data. Although the actual accuracy and utility of the data is questionable given their source [Tandy-Connor et al., 2018], this study showcases the vulnerability of consumers' information when uploaded to these databases. Additionally, it has been previously noted that as few as seventy-five SNPs are needed to correctly correlate a genetic sample with an individual [Liu et al., 2004].

In terms of regulation of the dissemination of information, the only law in place pertaining directly to the provisioning of genetic information is GINA. This federal law protects against discrimination on the basis of genetic information in the cases of employment and health insurance, but excludes other types of insurance and does not inform how DTCGT companies should handle their customers' information. These companies are also not subject to HIPAA constraints [King, J., 2019]. Therefore, the only privacy standards they are obligated to abide by are their own privacy policies which can be altered at any time by the companies themselves.

4.3 IMPLICATIONS FOR FIELD OF PRACTICE AND BEYOND

The motivations and expectations of consumers who underwent DTCGT and sought a genetic consultation for further analysis have not previously been well described in the literature. This study provides rich descriptions of the unique journeys each client took to gain a better understanding of their DTCGT results. Increasing awareness of these motivations and expectations will allow genetic counselors who work with this population

to better contract with clients to set realistic expectations and agendas for sessions. Additionally, these accounts provide counselors with insights into how clients have utilized the information shared in consultations and what they remember to be the most important points covered. These points of reflection can be used to modify individual practices, but also contribute to the larger, growing body of research that can help guide the formation of standardized guidelines for counselors working with this client population.

Perceptions of privacy influenced not only the testing company that clients chose but also how they interacted with their information. And yet, it seemed that the topic of privacy was not discussed comprehensively, or possibly not at all, with the genetic counselor or other health professionals since questions were posed to the researcher during the interview. Although some of these inquiries were framed more as curiosities rather than imminent concerns, the majority of clients were wary about the privacy of their genetic information. Additionally, clients' selection of a company that specifically advertises the protection of customers' privacy highlights the importance of this aspect to these consumers. As it seems clients are generally unaware concerning the privacy of their genetic information both inside and outside of the clinical setting, it is suggested that genetic counselors facilitate conversations surrounding the privacy policies of their practices and open the conversation for a broader discussion about privacy if the client so desires. This is not limited to genetic counselors meeting with clients specifically for the purpose of reviewing DTCGT results. Patients who express interest in DTCGT or bring these results with them to genetics clinic appointments should also be presented with the opportunity to discuss the privacy of their genetic information within the DTCGT and clinical settings.

Through exploring the experiences and perceptions of this unique DTCGT client population, it became evident that, prior to the genetic consultation, many clients perceived DTCGT to be a comparable substitution for clinical genetic testing. From seeking molecular diagnoses of conditions to seeking reassurance that there are no overt pathogenic variants of concern, clients sought definitive, concrete answers to their genetics questions through DTCGT companies. This points to the need to better educate the public about the differences between DTCGT and clinic genetic testing. Genetic counselors working with DTCGT clients seem to be filling this role well. However, this information needs to be disseminated to a broader audience so that those interested in genetics services who have not yet pursued testing can make more informed decisions concerning the type of testing they chose to pursue.

Additionally, these findings highlight the continued need to better educate the public about the roles of genetic counselors and geneticists. Only one of the eight clients had previous knowledge of genetic counseling in a clinical setting. Another informant turned to their usual physician in order to avoid the expenses associated with seeing a geneticist or genetic counselor. However, the provider would not order the testing and so the informant was left with the option of DTCGT to obtain the information she desired. Although further awareness of the specialized roles of genetic counselors and geneticists will not change the cost often associated with a specialist consult and subsequent genetic testing, it would emphasize the value of being seen and having testing ordered by a healthcare professional specifically trained in genetics. This informant's situation also calls to attention the need to educate primary care physicians, and other doctors who patients

may see regularly, about when to refer patients to a genetics clinic and, if a provider is comfortable, how to appropriately order genetic tests and interpret their results.

This interest of relatively healthy people to not only learn about their genetic information but also talk through it with a genetics professional also highlights the need for more providers who are willing and able to conduct this type of work. Although meeting with a genetics professional in a traditional clinical setting may be ideal for some people, specialty genetics clinics simply do not have the capacity to see each person who would like to have an exome ordered "just in case" or to discuss their DTCGT results. Individually, genetic counselors working in private practice who have experience interpreting reports by DTCGT companies and third-party services are well-equipped to handle this demand. However, few genetic counselors are currently participating in this line of work. In addition to individual practices, some health systems in the United States have also set up precision medicine clinics and programs aimed at providing clinical genetic screening to healthy patients. These differ from genetic consultations by private practice genetic counselors in that the genetic counselors facilitating the appointment are employed by the center sponsoring the program. Patients enrolled in these programs typically receive both pre-test and post-test counseling through a variety of modalities depending on the set up of the clinic [Manolio, T., 2017; Robbins, R., 2019; Sturm et al., 2018;]. Although these programs show promise in meeting the needs of healthy individuals who are curious about their genetic information, they are not yet widely available across the country and can require significant infrastructure to establish within health systems [Robbins, R., 2019].

4.4 LIMITATIONS

While the interviews conducted as part of this study produced valuable data concerning the experiences and expectations of this unique population, the study contains several limitations.

Clients were recruited from the practices of three genetic counselors, however the majority of respondents met with one specific counselor (GC 1 whose interview was used in triangulation). Additionally, although many participants submitted samples to multiple DTCGT companies, the majority only discussed the results from a single DTC whole-exome company. The demographics of the eight clients reflect those found in other studies that recruited participants who underwent DTCGT. However, interviews with participants of differing ethnic backgrounds and more varying levels of education may have provided more varied accounts of experience with DTCGT results and contributed unique perspectives. The eight clients included may also represent a uniquely motivated sample given that no incentive to participate was provided and informants' existing desire to contribute to research. This sample of eight clients and one genetic counselor provides valuable insights into the experiences of this population, but it does not satisfy the quality of rigor needed to achieve saturation. As a qualitative analysis, findings are also not applicable to all consumers who participate in DTCGT and seek out genetic consultation.

Additionally, informants' accounts of their experiences are self-reported and must take their accounts at face value. However, informants may have exaggerated or embellished parts of their accounts or may have withheld details. These alterations, whether conscious or subconscious, could be due to a number of different factors, including but not limited to selective memory, the relationship with or perception of the researcher,

inference about what the researcher desired to hear, and circumstances surrounding informants' personal life.

Expectations of the genetic consultation were also bounded by the fact that seven of the eight clients were not familiar with the practice of genetic counseling prior to the consultation. Many expressed vague ideas that the genetic counselor would go over their information, but they may have lacked the background knowledge to describe their exact expectations. Further probing may have revealed additional details describing client expectations held before the genetic consultation.

The researcher approached this study with an awareness of her training in clinical genetic counseling and other background factors; this may have led to bias in the interactions with the clients and therefore in the data collected. Unfortunately, analysis by an independent coder was not feasible for this project. Efforts to limit personal biases include the use of interview guides, the objective use of a theory, and comparing two distinct perspectives of an experience to triangulate data. However, personal perspectives may still have influenced the collection and interpretation of the data.

4.5 DIRECTIONS FOR FUTURE RESEARCH

As an exploratory study, there are many opportunities for future research in this area. The inclusion of additional genetic counselors serving this client population would enable more thorough documentation concerning how they are approaching consultations and talking to clients about DTCGT results. Contact with more than one counselor in this space would also provide insight into common difficulties or pitfalls they encounter, strategies used to prepare for sessions, and perceptions of the DTCGT market as a whole.

Furthermore, hearing from multiple counselors conducting genetic consultations would be useful in establishing key points that professionals outside of the specialty could use to educate their patients and the public about DTCGT.

It would be useful to examine how physicians and other health professionals would prefer to learn about DTCGT. Previous studies have shown that providers would like to learn more about how DTCGT results can be used, but the most effective methods to educate those interested have only begun to be explored. Giving professionals such as primary care physicians effective education and up-to-date resources to educate their own patients could have a great impact on the basic knowledge consumers hold before purchasing these tests or requesting specialized genetics services.

Additionally, research focused on perceptions of privacy protections in different professional settings, such as clinics versus research studies versus genetic consultations, could reveal insight on what aspects are most important, what type of information is best received, and which points are commonly overlooked. This would allow for a better understanding of the perception of privacy so that professionals could more effectively discuss the subject.

Finally, a better understanding of how information concerning DTCGT and clinical genetics are discussed and disseminated in the general population may help identify avenues to dissuade common misconceptions or refute myths about both fields. A more accurately educated population would hopefully mean that consumers and patients could be more discerning with information that could impact their present and future health.

4.6 CONCLUSION

This study contributes novel descriptions of the experiences and expectations of consumers who purchase DTCGT and pursue a genetic consultation for further analysis of their results. In the published literature, this population is rarely studied and has never been described outside of the context of larger research studies [Dasrt et al., 2013; Koeller et al., 2017] in which consultation with a genetic counselor was offered free of charge.

Understanding the initial motivations and expectations of these consumers is the first step in being able to properly interpret the outcomes of these sessions and improve the abilities of the counselors working in this space. This unique client population also provides insights into the challenges and questions that those wishing to learn more about their genetic information are facing and highlights the importance of better educating the public about their options for pursuing genetic testing.

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APPENDIX A

Client Interview Guide

1. How did you find out about genetic counseling? (Warm up question)
   a. Probe: What background knowledge did you have about genetic counseling?
   b. Probe: How did you find your genetic counselor?

2. What prompted you to send your sample in for genetic testing?
   a. Probe: What information did you seek out before doing the testing?
   b. Probe: What type of testing did you ultimately decide to have done?
   c. Probe: Tell me about what led you to send in your sample for testing, if you had any conversations with anyone -to whom did you turn and describe to me what those conversations were about, describe any events that shaped your decision to do the testing?

3. What about your results made you want to seek out more information?
   a. (if applicable) Probe: What prompted you to input your data into a third-party interpretation service?
   b. Probe: Tell me more about the information or clarification you were looking for from the genetic counselor.

4. What did you expect from the genetic counseling session?
   a. Probe: How well were your questions in the session answered?
   b. Probe: Please describe any parts of the session that were especially helpful or surprising.

5. What sticks out in your mind the most about the appointment?

6. How did you feel after the genetic counseling appointment?
   a. Probe: Anything you wish was discussed more?
   b. Probe: With whom have you talked about your genetic counseling session?
   c. Probe: How would you describe your comfort level with your results now?
   d. Probe: Did you feel the price of the session was worth what you got out of it?

**Demographic questions to be asked at the end of the interview. Questions will include age, self-identified ethnicity, state they live in, highest level of education, and occupation

APPENDIX B

Genetic Counselor Interview Guide

1. Walk me through what you do when you first receive a request for a genetic consultation.
    a. Has this process changed over time? Why?
    b. And how do you try to get a sense of what clients want from the session?
    c. Does your research change based on what clients communicate to you beforehand?

2. What change in your practice do you think has made the biggest difference to your clients?

3. What do you think makes a session successful?
    a. How do you prepare so that the session can be as successful as possible?

4. What are the main take-aways you try to emphasize with clients? What do you think they take away from the session?

APPENDIX C

Codebook

Theme	Code	Description	Notes
Seeking Information	Family History	Informant is concerned about health problems in their family history that may have a genetic etiology.	
	Optimize Health	Informant is looking for ways to keep themselves healthy and improve their health through their genetic information.	
	Shocking Result	Informant receives a result that they were not expecting or that worries them.	Not coded in GC1 interview
	Specific Concern	Informant names health concern(s) that they believe their genetic information will tell them more about.	
	Urgency	Describes the amount of urgency the informant attributed to reviewing their results with a genetic counselor.	Not coded in GC1 interview
	Wanting Confirmation	Informant undergoes DTCGT or meets with the genetic counselor to reinforce what they already knew about their genetic information or had found through their research.	
	Wanting Context/Meaning	Informant wanted the genetic counselor to give meaning to their data or analyze it in a way that is applicable to them. Includes feels of being overwhelmed by information returned.	
Frustration	Confusion	Informant expresses confusion about their results before or after the genetic consultation.	
	Consumer Feedback	Informant shared ideas that could help themselves or other people in their DTCGT journey. Does not apply to feedback on genetic counseling sessions.	Not coded in GC1 interview
	Expense	Informant makes reference to the cost of DTCGT, third-party interpretation services, clinical genetics services, or clinical genetic testing.	Not coded in GC1 interview
	Hoped for More	Informant wishes there was more information available or that they could get more answers from the DTCGT data.	
	Physician Reluctance	Informant feels that clinical healthcare is not amenable to their needs/wants.	Not coded in GC1 interview

Questioning	Critical Reflection	Informant examines how their perception of their genetic information changed after the genetic consultation.	
	Privacy	Informant expresses their view on the privacy of their genetic information.	Not coded in GC1 interview
	Skepticism	Informant expresses skepticism about the genetic consultation or their genetic data.	Not coded in GC1 interview
Satisfaction	Gained Skill	Informant describes a practice or skill that the genetic counselor taught them.	Not coded in GC1 interview
	Genetic Counselor Disposition	Informant describes their perception of the genetic counselor	Genetic counselor did not comment on how she believes she is perceived by clients
	Personalization	Informant described how the genetic counselor tailored the session	
	Providing Context/Meaning	Informant recalls genetic counselor explaining results to them in a way that made more sense. Includes giving background information, reordering priorities, and talking about a specific variant.	
	Reassurance	Informant felt reassured about their results after talking with the genetic counselor.	
	Recreation	Informant views DTCGT or information as side-interests or something to do to keep them busy.	Not coded in GC1 interview
	Relief	Informant expresses that their worries were alleviated after the genetic consultation.	
	Validity	Statements inform how valid a consumer believes their DTCGT results are.	
Hopefulness	Actively Seeking More	Informant describes how they sought out more data or interpretation of the data after the genetic consultation. Could be in a DTCGT or clinical format.	
	Desire to Advance Research	Informant hopes that their data can be used by researchers or their data can advance genetics in some way.	Not coded in GC1 interview
	Fascination/Excitement	Encompasses statements and behaviors that convey a fascination and excitement for the field of clinical genetics or information from DTCGT.	
	Future of Genetics	Informant make reference to how advancements in genetics will affect the future either in general or for them personally.	