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Examining Psychological Outcomes Associated with Genetic Testing for Primary Arrhythmic
Disorders in Adult Patients

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1. ABSTRACT

The psychological impact of genetic testing for an inherited arrhythmia and its influence on future well-being is highly variable and has not been well studied. Thirty-seven participants completed a survey which included questions from the Multidimensional Impact of Cancer Risk Assessment (MICRA) questionnaire, Impact of Events Scale (IES) and Satisfaction with Decision Scale (SWDS) to provide more information on their genetic testing experience and to allow the authors to search for trends that may improve the genetic counseling experience moving forward. Trends were seen upon the comparison of those who had positive versus negative genetic testing results. Those with positive test results seemed to have higher stress scores and experienced a greater psychological impact. While more investigation is needed, this study serves as a good starting point to understanding the experience of genetic testing for these individuals.

Keywords: Cardiac Arrhythmias, Genetic Testing, Psychological Impact

2. INTRODUCTION

In recent years, genetic testing has become widespread in its application within healthcare specialties that involve potentially heritable disorders. Several factors have contributed to it becoming a more accessible tool in the management and care of families with inherited conditions including advances in disease gene identification, the declining cost of genetic testing and laws that protect patients from being discriminated against by employers and health care providers based on genetic testing results. Cardiac genetics in particular is a growing field that can provide more information to families with a suspected inherited cardiac condition.

There are many reasons why someone may choose to undergo genetic testing for cardiac conditions such as long QT syndrome (LQTS), short QT syndrome (SQTs), catecholaminergic polymorphic ventricular tachycardia (CPVT) or Brugada syndrome (BS). The major benefits of testing are enhanced medical management guidance and the ability to recommend medications or other interventions to prevent sudden cardiac death (SCD). It can also be used to confirm a diagnosis in an individual who is symptomatic, or to provide a more accurate risk assessment for asymptomatic family members. When deciding whether to have a genetic test, it is important that individuals consider not only the medical benefits, but also the potential emotional impact. By recognizing certain characteristics associated with negative psychological well-being following a positive genetic test result, genetic counselors can address these issues during pre-test sessions to better prepare patients for the potential impact of this result. Resources can also be put in place to assist individuals who are struggling to cope with this new information. Overall, improved understanding of the psychological implications of genetic testing in families with inherited cardiac conditions and the effect that testing can have on health-related quality of life (HR-QoL) can help tailor pre-test genetic counseling to best meet the needs of the patient.

3. BACKGROUND

Sudden cardiac death and primary arrhythmic disorders

Sudden cardiac death is defined as a natural, unexpected death due to abrupt loss of heart function in an otherwise healthy individual. It typically occurs within an hour after the onset of symptoms, although it can also occur without any warning symptoms at all. Each year, more than 300,000 people die of SCD in the United States alone, making it a major health concern not only in the United States, but also worldwide (Fishman *et al.*, 2010). A subset of SCD is the result of

a heart rhythm disorder known as an arrhythmia, which is defined as an irregular heartbeat (Sarkozy & Brugada, 2005). Accordingly, the ability to identify an inherited arrhythmic condition within a family may aid in the treatment and prevention of numerous SCDs.

Inherited arrhythmic conditions, also known as primary arrhythmic disorders, are a group of monogenic syndromes characterized by genetic and pathophysiological heterogeneity. Despite their unique clinical presentation, the syndromes share many common genetic counseling issues including an autosomal dominant pattern of inheritance, variable age of onset, incomplete penetrance, and increased risk of SCD (Ingles *et al.*, 2012). The understanding of primary arrhythmic disorders has advanced significantly in the last 20 years due to the discovery of mutations in ion channel genes. This gives a genetic basis to a number of these disorders, many of which were previously considered to be idiopathic. Genetic mutations in ion channel genes alter the proper movement of ions through highly regulated channels that generate cardiac action potentials, leading to dysfunction which can manifest itself as electrocardiogram (ECG) abnormalities, arrhythmias and sudden death. Syndromes characterized by ion channel dysfunction, commonly referred to as “channelopathies”, have been the focus of numerous studies following the identification of ion channel mutations which underlie specific heritable arrhythmic disorders. These include LQTS, BS, SQTS and CPVT (Wilde & Bezzina, 2005).

Psychological effect of genetic testing

Although genetic testing for some conditions has the potential to lower related morbidity and mortality rates through increased surveillance and treatment, studies have questioned whether it may also lead to increased distress, anxiety, depression and worry. Conditions that exhibit reduced penetrance, such as inherited cancer syndromes or inherited cardiac disease, appear to be of particular interest since test results only indicate a predisposition rather than a

definite diagnosis (Heshka, Palleschi, Howley, Wilson & Wells, 2008). At this time, there is not a significant amount of literature that examines the psychological impact of cardiac genetic testing. However, much has been published on psychological well-being for those who have genetic testing for inherited cancer predispositions. There are similarities between the two patient populations, allowing the extensive cancer research to help inform research on the psychological effect of cardiac genetic testing.

Genetic testing for inherited cancer syndromes

Most short term studies noted, regardless of a patient's test result, whether positive, negative or a variant of uncertain significance (VUS), that by the end of the follow-up time period of one year, levels of psychological distress regarding BRCA1/2 testing were stable (Graves *et al.*, 2012).

Longer term follow-up prospective studies did find, however, that the level of distress in mutation carriers can be elevated above what is seen in a control group, or a group of women who tested negative. Graves *et al.* found that, about five years after genetic testing was conducted, women who received a positive result reported greater distress from the test than those who received a negative or uninformative result. The authors attributed this difference to the sensitivity of the instrument, the MICRA (Multidimensional Assessment of Cancer Risk Assessment) questionnaire, which was used to look at distress, uncertainty and positive experiences related to genetic testing (Graves *et al.*, 2012).

The impact that a genetic testing result has on an individual is also dependent on their baseline level of anxiety and worry coming into the appointment, which is thought to be the most robust predictor of psychological well-being. Factors that can cause increased anxiety or worry include a history of clinical depression, psychiatric major or minor depression,

psychopharmacologic medication use, higher pre-test anxiety, and higher levels of distress at the time of testing (Hirschberg *et al.*, 2015).

In 2009, a study by Ertmanski *et al.* looked to analyze the levels of pre-test and post-test anxiety in women. According to the study, levels of anxiety following genetic testing were similar to the levels of anxiety before testing. That level tended to remain elevated following the receipt of a positive genetic testing result. No increased anxiety was associated with the news of a positive genetic testing result, but no decline was seen either (Ertmanski *et al.*, 2009).

The type of coping mechanism a patient uses to deal with genetic testing information will affect their level of anxiety as well. Passive coping, where individuals rely on others to resolve stress, is associated with increased stress and is connected to future distress for the patient. Avoidant coping can also be associated with future distress, irrespective of a patient's genetic test result or health history (Hirschberg *et al.*, 2015). Those who are more aware of their risk going into genetic counseling and genetic testing reported lower distress following the results (Marteau & Croyle, 1998).

Genetic testing for inherited cardiac conditions

Although the majority of published studies that examine the psychological implications of having genetic testing predominantly focus on inherited cancer syndromes, the literature has started to examine these measures for more common cardiac conditions such as hypertrophic cardiomyopathy (HCM) and LQTS in recent years.

A cross-sectional study by Christiaans *et al.* found that quality of life and psychological distress in 228 HCM mutation carriers did not differ from the general Dutch population and in fact, HCM mutation carriers without symptoms had even higher quality of life than the general Dutch population. They also suggested that genetic testing had no adverse effects on these

measures, and may have even improved them. Several study participants spoke to the benefits of knowing their genetic test results with one saying, “Since I received my DNA test result, I have found more peace and I am more positive,” suggesting they have less distress and a better quality of life after genetic testing (Christiaans *et al.*, 2009).

Similarly, a longitudinal pilot study by Ingles *et al.* examined changes in HR-QoL of 33 patients and 21 family members undergoing predictive genetic testing for an inherited cardiomyopathy or primary arrhythmic disorder. This study found that physical and mental health scores analyzed at baseline and one to three months after testing were unchanged in participants, regardless of their mutation status. Additionally, no changes in HR-QoL were observed in the participants following genetic testing and up to 12 months after results disclosure regardless of their mutation status (Ingles *et al.*, 2012).

Hendriks *et al.* assessed the extent and course of disease-related anxiety and depression, caused by predictive genetic testing in 77 patients and 57 partners from the time of first consultation until 18 months after the disclosure of the result of genetic testing. In an initial consultation, family history and ECG results were used to give individuals a presumptive diagnosis. This study found that individuals with an uncertain ECG result had higher levels of depression than those with a normal or even an abnormal ECG. They also found that after disclosure of the genetic testing results, carriers had higher anxiety than non-carriers, especially among those who had had an uncertain ECG result. Overall, this study found that individuals who underwent predictive genetic testing experienced higher levels of distress initially, but distress levels were essentially restored within 18 months of results disclosure, unless the patient was also found to have an uncertain ECG, in which case the higher levels of distress persisted (Hendriks *et al.*, 2008).

Purpose

Current studies suggest that genetic testing, accompanied by genetic counseling, for inherited cancer syndromes or cardiac conditions does not appear to have any long term impact on psychological well-being or quality of life, regardless of mutation status. Despite this, very little research has examined the psychological impact of genetic testing for primary arrhythmic disorders such as LQTS, SQTS, CPVT or BS which may present differently with regard to treatment, prognosis, time of onset and associated symptoms. Despite the ability to utilize the current knowledge on inherited cancer syndromes to guide a hypothesis with respect to arrhythmias, no research has been done to directly address this question. This study examines the psychological well-being and HR-QoL of adults who had genetic testing for LQTS, SQTS, CPVT or BS and further describes this population by analyzing responses to questions from validated instruments including the Impact of Events Scale (IES), the Satisfaction with Decision Scale (SWDS) and the MICRA questionnaire.

4. METHODS

This is a qualitative, survey-based study that examines the impact that genetic testing has on an individual's psychological well-being and their HR-QoL. Psychological well-being is assessed through scales that measure anxiety, depression, parenting stress and decision regret. HR-QoL is assessed through examinations of family functioning, marital relationships, self-inflicted restrictions and life-planning decisions.

Columbia University Medical Center's study was approved by the Columbia University Institutional Review Board and the current study was approved by the Sarah Lawrence College Institutional Review Board.

Participants

Participants are Dr. Wendy Chung's clinical patients and their family members who were referred for genetic testing for arrhythmic disorders over the last six years. Inclusion criteria include an appointment in the past 12 years for a personal or family history of BS, LQTS, CPVT or SQTs. Exclusion criteria include inability to speak/read English, no working contact phone number or a non-genetic systemic disease causing cardiac findings (i.e. myocarditis). Study participants include: adults (greater than 18 years of age) who are symptomatic with evidence of cardiac disease or asymptomatic with a known family history of cardiac disease; adults (greater than 18 years of age) who are a spouse or significant other to an individual with a known family history of cardiac disease; adolescents (greater than 13 years of age, but less than 18 years of age) who are symptomatic with evidence of cardiac disease or asymptomatic with a known family history of cardiac disease; and parents of children (younger than 13 years of age) who are symptomatic with evidence of cardiac disease or asymptomatic with a known family history of cardiac disease.

Data collection

Participants were identified through an existing clinical database of patients evaluated at Columbia University Medical Center Clinical Genetics for an inherited cardiac condition. Eligible participants were sent invitation letters from Dr. Wendy Chung which outlined the proposed study. One letter was sent to each household, which sometimes included multiple individuals who were eligible to participate. The letter was followed by up to five telephone calls or emails from a research coordinator to invite the individual and their eligible family members to participate. Individuals who did not respond to five follow-up phone calls or emails were considered to have passively declined participation. A passive decline was considered

“confirmed” if it was verified that this was the correct number for the individual trying to be reached (i.e. name in the voicemail, spoke to someone in the household). A passive decline was considered “unconfirmed” if the phone number for the individual trying to be reached was not verified (i.e. no name in the voicemail message). Individuals who responded that they did not want to complete the survey were considered to have actively declined from participating.

The survey could be completed online, over the phone or by paper in written format. Verbal consent to participate was obtained by telephone by the research coordinator for all participants. For participants who chose to complete a paper survey, the consent form was mailed to them with the questionnaire. For those who chose to complete the survey online at surveymonkey.com, the consent form appeared prior to the start of the questions. Individuals who completed the survey were compensated with a \$20 gift card for each questionnaire completed. The survey became available on October 8, 2015. At this time, there is no planned end date. Data for analysis was collected between October 8, 2015 and March 7, 2016.

Study instruments

This study utilized four questionnaires that are unique to the groups of individuals completing them. The four groups are: adults with a personal or family history of arrhythmias, adults who married into a family with a history of arrhythmias, adolescents with a personal or family history of arrhythmias, and children with a personal or family history of arrhythmias. The corresponding questionnaires consist of 54, 56, 42 and 38 questions respectively. All questionnaires have demographic, medical, genetic testing, life restriction, discrimination and genetic knowledge questions, in addition to specific validated instruments (Table S1).

Outcome measures

Several validated scales were included in the adult patient survey which are the primary outcome measures of this study. The MICRA questionnaire and the IES identify the impact of genetic test results, while the SWDS determines satisfaction with having or not having genetic testing. Understanding of genetic testing was also analyzed. Secondary outcome measures include the influence of age and genetics knowledge on the primary outcome measures.

The MICRA Questionnaire

The MICRA questionnaire was developed in 2002 as a way to assess the specific impact of result disclosure after cancer genetic testing. It sought to fill gaps left by other standardized questionnaires of the time, by asking specific questions about one's test result and assessing the impact it has on cancer risk as well. This validated tool consists of 25 questions, each with four possible responses: never, rarely, sometimes and often. The questions are to be answered based on feelings within the week of completing the questionnaire. There are 21 questions that must be answered by all participants and four questions that are answered depending on one's parental status, test results and cancer diagnosis. The MICRA questionnaire is composed of three subscales that assess distress, uncertainty, and positive experiences (Cella *et al.*, 2002). The questions in this study were modified to be relevant for our patient population, substituting 'cardiac disease risk' in place of 'cancer risk' where appropriate.

The Impact of Events Scale

The IES was developed over 35 years ago to measure subjective distress in response to a specific event. This scale is a short, easily administered self-report questionnaire that is composed of 22 questions. It contains three subscales: intrusion (intrusive thoughts, nightmares, intrusive feelings and imagery), avoidance (numbing of responsiveness, avoidance of feelings,

situations, and ideas) and hyperarousal (anger, irritability, hypervigilance, difficulty concentrating, and heightened startle). The IES is a widely used, validated screening tool that measures stress reactions after traumatic events such as natural disasters, war, terrorist attacks, or sexual/physical assault, among other things. It can be used repeatedly to assess distress in response to an event over time and allows investigators to examine the degree of distress imposed by a particular life event in different populations of individuals, giving it the potential to provide valuable information in a variety of situations (Horowitz, Wilner & Alvarez, 1979).

The Satisfaction with Decision Scale

The SWDS was designed to measure satisfaction with respect to health care decisions. It has three major purposes: 1) to measure satisfaction with the decision, ensuring the decision is informed, consistent with the individual's values, and behaviourally implemented; 2) to distinguish satisfaction with decision from satisfaction with other aspects of health care; and 3) to be short and easy to use. This six-item scale is a reliable and valid instrument that is closely related to a patient's intention to act. It can also be used to gauge an individual's contentment with a decision they have already made (Holmes-Rovner *et al.*, 1996).

Data analysis

The data was collected and organized through Survey Monkey and Microsoft Excel. IBM SPSS Statistics was used to analyze the data. The MICRA questionnaire, IES and SWDS were analyzed for internal consistency with Cronbach's alpha. The mean, standard deviation, and range were calculated for each scale. A linear regression was performed to analyze outcomes measures comparative to age and genetics knowledge. P values were based on the Kruskal-Wallis test.

5. RESULTS

A total of 91 unique families were invited to participate in the study. Within these families, 141 individuals were reached. From those reached, 106 individuals consented to participate in the study and each was sent a survey to complete. Of those who agreed to participate, 61 individuals completed the survey. Accordingly, 45 individuals consented to complete a survey, but did not. One individual was considered to have actively declined as she indicated she was not interested in participating. There were four confirmed passive declines and 16 unconfirmed passive declines. Six individuals did not speak English and two did not have working contact information. Unfortunately, one individual had passed away at the time of contact. Based on the above numbers, the enrollment rate (individuals consented/individuals invited) is 75% and the response rate (surveys completed/individuals invited) is 43%.

Of the 61 completed surveys, 36 were adult patient, 16 were child, five were adolescent and four were adult married-in surveys. A total of four surveys were partially completed; one was an adult patient, one was a child and two were adult married-in surveys.

Demographics

With regard to the adult patient population, 37 individuals started the questionnaire. It was fully completed by 36 individuals, while one left it partially complete. All 37 participants answered the demographics section. Of these 37 participants analyzed, the mean age was 41 with a range of 19 to 62 years. With respect to gender, 62% were female and 38% were male. In terms of race, 81% of participants identified as White. In regards to country of origin, 70.3% of participants were born in the United States of America. Other countries of origin include Romania (2.7%), Palestine (8.1%), Dominican Republic (2.7%), South Korea (2.7%), Montenegro (2.7%), Germany (2.7%), The Philippines (2.7%), The Netherlands (2.7%), and

Hungary (2.7%). When asked about educational background, 35% of individuals indicated they had received a Master's/Doctoral/some graduate degree. With regard to employment, 68% of participants reported being employed full time (Table I).

The MICRA questionnaire

The MICRA questionnaire was completed by 35 of the 37 participants, as two individuals indicated they did not have genetic testing and it was not applicable to complete the MICRA questionnaire. The internal reliability of the subscales had high internal consistency, except for the positive experiences subscale which had a split-half reliability coefficient of 0.53. The mean of the distress subscale was 3.0. The mean of the uncertainty subscale was 5.4. The mean of the positive experience subscale was 7.4 (Table II).

The IES

The IES was completed by 34 of the 37 participants. Two individuals did not have genetic testing and therefore this scale was not applicable. One individual failed to complete this scale as they only partially completed the survey. All of the subscales had high internal consistency. The mean of the intrusion subscale was 3.2. The mean of the avoidance subscale was 3.6. The mean of the hyperarousal subscale was 1.8 (Table II).

The SWDS

The SWDS was completed by 36 of the 37 participants. One individual failed to complete this scale as they only partially completed the survey. The reliability was very high at 0.99. The mean score for this scale was 20.8 (Table II).

Primary outcome measures

The IES has a scoring range of 0-88. The minimum stress score for the scale as a whole was zero, the maximum was 48 and the mean was 8.6. The SWDS has a scoring range of 5-25.

The minimum score regarding satisfaction with decision was five, the maximum was 25 and the mean was 20.8. The MICRA questionnaire has a scoring range of 0-125. The minimum score was one, the maximum score was 69 and the average score was 24.0 (Table III).

A total of nine participants (24.3%) had a positive result, 24 (64.9%) had a negative result and four (10.8%) did not have testing. Individuals who had a VUS were categorized as either negative or positive depending on the pathogenicity of the specific variant.

Genetic test results do appear to have a significant impact on stress scores as the mean stress scores for individuals with a positive result were elevated over those with negative results for all three IES subscales as well as the IES as a whole. Additionally, individuals who did not have genetic testing had stress scores that were higher than individuals with negative results, but less than individuals with positive results (Table IV).

Overall, genetic test results were seen to have a significant effect on the psychological impact of testing for cardiac disease risk. There was a significance seen with the uncertainty and distress subscales of the MICRA questionnaire as well ($p < 0.05$ for MICRA questionnaire total, Uncertainty and Distress subscales). Genetic test results were not seen to have a significant impact on positive experiences regarding the testing process for cardiac disease (Table IV).

Genetic test results do not appear to have a significant effect on an individual's satisfaction with their decision to either have or not have genetic testing, nor do they have any impact on a participant's genetic knowledge (Table IV).

Thirty-five individuals completed question 22 of the adult patient survey which asked if participants felt sufficiently informed when undergoing genetic testing. Thirty-two of the 35 individuals (91.4%) felt sufficiently informed when they had genetic testing. Only three individuals (8.6%) felt as though they understood what it meant to have genetic testing, but more

information would have been helpful. Unfortunately, the option to elaborate on additional information that might have been helpful was not available. None of the participants felt as though they had not been sufficiently informed at the time of testing, nor did anyone feel unsure of the information provided, or not realize that genetic testing was performed (Figure 1).

Secondary Outcome Measures

Age was not seen to have an impact on stress scores, psychological impact of cardiac disease diagnosis, one's satisfaction with their decision or one's genetic knowledge as $p > 0.05$ for all measures (Table V).

Genetic knowledge was not seen to have a significant impact on stress scores, psychological impact of cardiac disease risk or satisfaction with one's decision as $p > 0.05$ for all measures (Table VI).

6. DISCUSSION

The goal of this study was to describe the experiences of a population of patients who have undergone genetic testing for primary arrhythmic disorders, focusing on the psychological outcomes and HR-QoL. In addition, this study aimed to examine participants' understanding of their results as well as assess their knowledge with regard to genetic concepts.

Understanding

Most participants correctly reported their genetic test results suggesting that genetic counseling and results disclosure were sufficient and effective. With that being said, some discrepancies were seen. Two participants reported having negative genetic testing results, when in fact, no testing was conducted. Participants who did not have genetic testing should have skipped questions involving the MICRA questionnaire and the IES. Because these individuals

thought they underwent genetic testing, they provided answers to questions regarding their experience with genetic testing without ever actually having an experience to draw upon. This is evident in Table IV where the “No Testing” category for the MICRA questionnaire and IES should be blank, yet the data present is an average of the responses of these two individuals.

All 35 participants indicated that they were aware that they were having genetic testing. Thirty-two of these individuals said they were given sufficient information to understand what that meant while the remaining three individuals felt as though they understood, but more information would have been helpful. When asked to recall the results of their genetic testing, the majority (31/35) of participants reported results that were consistent with those found in the Columbia University Medical Center database. Four individuals reported results that were inconsistent for different reasons. As mentioned above, two participants reported having negative genetic testing results, when in fact, no testing was conducted. One indicated that his result was uncertain, yet the database showed that he had a negative result. One individual reported that the results of the testing were unclear to her, but her results in the database were negative. This individual was the only one to indicate that she did not understand her genetic testing results, while the other three individuals, who clearly did not understand, claimed that they did. This suggests that there was not sufficient information provided to these individuals during their genetic counseling sessions for them to fully understand their results.

The MICRA questionnaire

Overall, the participants receiving genetic testing for arrhythmias did not report negative psychological experiences on the MICRA questionnaire, with an average score of 24. Only one individual had a score greater than 50% of the maximum score at 69/125. This is the highest

score seen within the cohort and may suggest that this individual is at an increased risk for future distress.

In general, those with negative results or those who did not undergo genetic testing were seen to have lower average scores than those who tested positive, which was significant ($p < 0.05$). On average, these participants reported rarely feeling distressed or uncertain about their genetic test results within the last week, with an average score of 3.0.

The IES

The average stress score following genetic testing as reported on the IES was 8.6 out of a maximum of 88 points. Of the 34 participants, 12 (35%) reported an overall stress score of zero and 23 (67%) reported a score less than 10. Accordingly, the majority of participants experienced little to no distress for each of the 22 difficulties listed on the IES that are commonly encountered after stressful life events. For this scale, scores that exceed 24 can be quite meaningful. For a score greater than 24, post-traumatic stress disorder (PTSD) becomes a clinical concern, a score of 33 is the best cutoff for a probable diagnosis of PTSD, and a score that exceeds 37 is enough stress to suppress immune system functioning. Of the 34 respondents, four individuals reported scores above 24. Three of these individuals had received a positive result and their stress scores were 29, 41 and 48. The fourth individual had not had genetic testing and reported a stress score of 34, however it should be noted that this individual believed that she had genetic testing and was negative. In general, this trend suggests that participants with positive results were more likely to have significant stress scores.

It was also found that genetic testing status (testing versus no testing) and genetic test result have a significant impact on stress score for all three IES subscales as well as the IES as a whole. Individuals with negative results had the lowest stress scores, individuals with positive

results had the highest stress scores and individuals who had not had genetic testing had stress scores in between these. A comparison of stress scores for positive results with those for no genetic testing shows that these values are quite similar, which is expected.

Additionally, participants who completed the IES were categorized into two groups depending on whether they themselves were the proband or if their child was the proband. The average overall stress score for participants whose child was the proband was 9.58, which is slightly higher than the stress score of 7.67 for participants who were the proband. This suggests that adults were slightly more stressed if it was their children who came to medical attention first, rather than themselves.

The SWDS

Of the 36 participants who completed the SWDS, 31 (86%) were satisfied with their decision to either have or not have genetic testing. One individual was neither satisfied nor dissatisfied with their decision, and four individuals were not satisfied with their decision. Of these four, three were negative and one was positive. This suggests that test result does not alter one's satisfaction with their decision, especially because the individuals who are dissatisfied are not all positive, which one would assume would be the group most likely to be dissatisfied. Further examination of responses to other survey questions for each of these four individuals did not identify any commonalities as to why they would all be dissatisfied.

The average overall satisfaction score for participants whose children were the probands was 21.17, which is essentially no different than the satisfaction score of 21.47 for participants who were the probands.

Limitations

As this was a pilot study, limitations were noted during this process. Due to constraints at the start of the project, we were only able to collect data on 37 individuals. While this is a good starting point to analyze trends in the data, a larger cohort is needed to allow for more detailed analysis and greater generalizability of the results.

The IES consists of a list of 22 difficulties that people may experience after distressing life events. Participants are typically asked to assess how distressing each difficulty has been within the last week since the occurrence of the event. In our study however, the life event of genetic testing occurred anywhere between three months to seven years ago. Accordingly, it is possible that having more time pass since the testing has dulled the emotions, feelings, worries or concerns. Participants have returned to daily life and it is possible that they do not experience things as intensely as they likely had one week after testing which is the time frame this scale is typically used for. Similar limitations are present with the MICRA questionnaire as well.

The data was stratified to look at those who were tested within a year versus those tested outside a year. While it is uncertain if this is statistically significant, differences were seen in both the average MICRA questionnaire and IES scores. Individuals tested within a year had an average MICRA questionnaire score of 28.9 and an average IES score of 12.1. Those tested outside of a year had an average MICRA questionnaire score of 22.5 and an average IES score of 7.6. Despite this observation, the highest and lowest MICRA questionnaire scores and the highest IES score were seen in individuals who were tested more than a year ago. Accordingly, it is uncertain what the difference in average scores means, if anything.

A difficulty that was encountered throughout the project was completion of the questionnaire following the consent process. Follow up was done through email, so there is a

chance that the survey links and/or follow up emails did not reach the participants, with the possibility of emails being transferred to a participant's junk email folder.

One limitation with the questionnaire itself was that it had to be completed in one sitting. Most individuals were able to do so; however, there were a few who did not realize this and would leave the survey partially completed.

Lastly, many of the validated instruments ask participants to think back to when they received their genetic testing results. Some individuals did not remember receiving genetic testing results and this would influence their response to those questions.

Implications for practice

By understanding what factors cause patients to become more anxious following genetic testing, we can help prepare them for what may arise after testing and results disclosure by addressing these factors beforehand during the pre-test counseling. Additionally, knowing if a patient is highly anxious prior to the session may influence HR-QoL and psychological well-being following results disclosure. This enables genetic counselors to tailor their sessions appropriately and employ counseling techniques that can better prepare the patient for the potential impact of their results.

Implications for future research

This study, which assessed psychosocial outcomes for individuals who had genetic testing for primary inherited arrhythmias, was the first pilot study of its kind. It was designed to assess baseline levels of psychological impact within an adult population. Future studies can be more focused on different groups of individuals, assessing for certain hypotheses.

Conclusion

Through this study, we were able to see correlations between a genetic testing result and the degree of psychological impact of that result, whether through stress scores or level of anxiety surrounding cardiac disease risk. In general, higher stress scores were seen for those who were positive, yet the majority of individuals reported receiving adequate information during their genetic testing process with minimal psychological impact. This shows that the amount of information provided to a patient during a genetic counseling session is sufficient for patients and results in relatively few psychological effects. Future studies that utilize a larger patient population will allow for more meaningful results with respect to HR-QoL and psychological well-being, as well as additional relevant psychological outcomes. In turn, these results have the ability to impact clinical management and results disclosure sessions while also enhancing patient education and increasing awareness of the genetic counseling field.

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Table I: Adult Demographics

Demographic	Options	N	%
Gender	Male	14	37.8
	Female	23	62.2
Age	Below 50	28	75.7
	Above 50	9	24.3
Race	White	30	81.1
	Black/African American	0	0
	Asian/Pacific Islander	2	5.4
	American Indian/Alaska Native	0	0
	Hispanic/Latino/Spanish	3	8.1
	Other	2	5.4
Highest level of education	Did not graduate high school	1	2.7
	High school graduate or GED	3	8.1
	Some college (vocational, technical, associate's degree etc.)	11	29.7
	College Graduate	9	24.3
	Master's degree/Doctoral degree/some graduate degree	13	35.1
Main daily activities and/or responsibilities	Employed full-time	25	67.6
	Working for wages or salary part-time	4	10.8
	Unemployed or laid off	1	2.7
	Keeping house or raising children full-time	3	8.1
	Temporarily disabled	1	2.7
	Other	3	8.1

Table II: Internal consistency of the MICRA questionnaire, IES and SWDS and subscale results

	Cronbach's alpha	Mean	Standard Deviation	Range
MICRA Distress	0.85	3.0	5.0	0-22
MICRA Uncertainty	0.79	5.4	6.8	0-25
MICRA Positive Experiences	0.80	7.4	6.3	0-20
IES Intrusion	0.92	3.2	4.9	0-19
IES Avoidance	0.88	3.6	5.1	0-22
IES Hyperarousal	0.90	1.8	3.3	0-13
SWDS	0.99	20.8	6.0	5-25

Table III: Summary of Outcome Measures

	N	%	Mean	St Dev	Min	Max	95% CI low	95% CI high
IES Intrusion	34	91.9	3.2	4.9	0	19	1.5	4.9
IES Avoidance	34	91.9	3.6	5.1	0	22	1.8	5.3
IES Hyperarousal	34	91.9	1.8	3.3	0	13	0.7	3.0
IES Total	34	91.9	8.6	12.3	0	48	4.2	12.9
SWDS	36	97.3	20.8	6.0	5	25	18.7	22.8
MICRA Distress	35	94.6	3.0	5.0	0	22	1.2	4.7
MICRA Uncertainty	35	94.6	5.4	6.8	0	25	3.1	7.7
MICRA Positive Experiences	35	94.6	7.3	6.3	0	20	5.2	9.5
MICRA Total	35	94.6	24.0	15.3	1	69	18.8	29.3
Genetic Knowledge	36	97.3	8.5	1.8	4	10	7.9	9.1

Table IV: Relationship between outcome measures and genetic test results (all patients)

	Genetic Testing, Positive (1)		Genetic Testing, Negative (2)		No Genetic Testing		Non-parametric group comparison (p) with ties
	Mean	SD	Mean	SD	Mean	SD	P value
IES Intrusion	7.4	5.8	0.77	1.7	8.0	7.0	p<0.001
IES Avoidance	7.3	6.7	1.9	3.3	4.7	5.7	p<0.01
IES Hyperarousal	4.7	4.8	0.45	1.1	3.3	4.2	p<0.001
IES Total	19.4	16.1	3.1	4.9	16.0	16.7	p<0.01
SWDS	20.9	6.4	20.4	6.4	22.5	2.9	p=0.93
MICRA Distress	7.7	7.6	1.4	2.2	0.67	0.58	p<0.01
MICRA Uncertainty	10.9	7.5	4.0	5.7	0.33	0.58	p<0.05
MICRA Positive Experiences	6.3	4.4	7.1	7.0	12.3	3.2	p=0.28
MICRA Total	38.1	16.9	19.8	12.0	14.7	4.6	p<0.05
Genetic Knowledge	8.6	1.3	8.4	2.1	8.5	1.7	p=0.97

Table V: Linear Regression of Outcome Measures vs. Age

	Constant	Coefficient for age	P value
IES Intrusion	8.3	-0.12	0.14
IES Avoidance	9.5	-0.14	0.09
IES Hyperarousal	5.4	-0.09	0.12
IES Total	23.3	-0.35	0.09
SWDS	18.8	0.05	0.61
MICRA Distress	3.8	-0.02	0.81
MICRA Uncertainty	4.5	0.02	0.85
MICRA Positive Experiences	9.3	-0.05	0.66
MICRA Total	24.8	-0.02	0.94
Genetic Knowledge	8.4	0.00	0.92

Table VI: Linear Regression of Outcome measures vs. Genetic Knowledge

	Constant	Coefficient for knowledge	P value
IES Intrusion	1.83	0.16	0.73
IES Avoidance	5.18	-0.19	0.69
IES Hyperarousal	0.73	0.13	0.68
IES Total	7.74	0.10	0.94
SWDS	24.77	-0.47	0.41
MICRA Distress	1.75	0.14	0.77
MICRA Uncertainty	1.70	0.43	0.51
MICRA Positive Experiences	6.54	0.11	0.85
MICRA Total	19.16	0.55	0.71

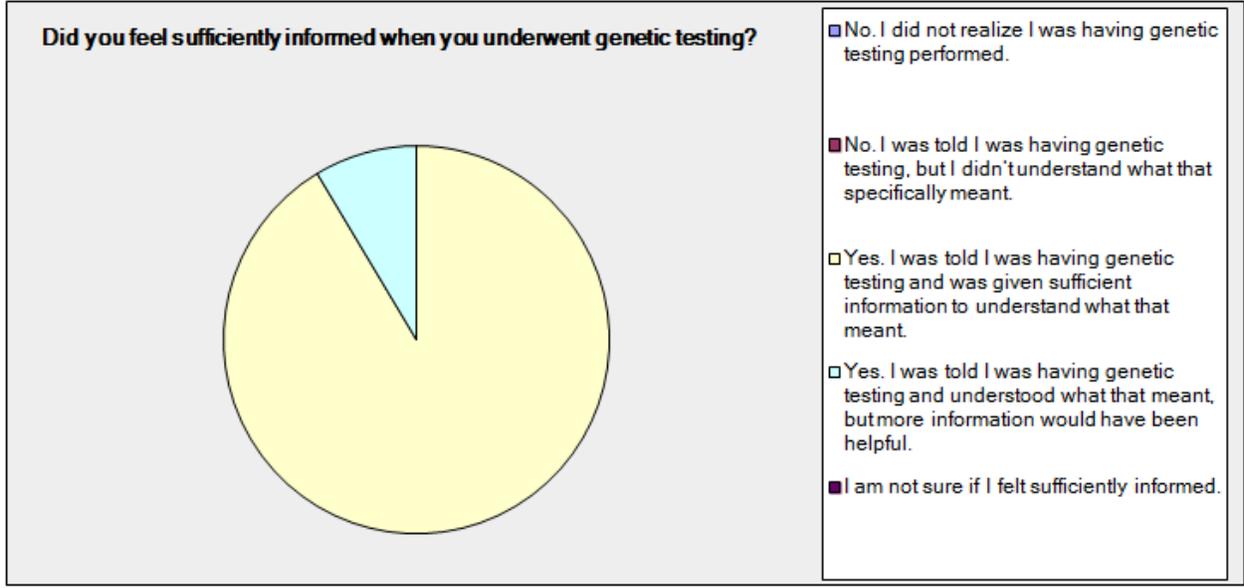


Figure 1. Question 22 - Did you feel sufficiently informed when you underwent genetic testing?

Supplementary Tables

Table S1: Study instruments utilized in each of the four questionnaires

Instrument	Adult Proband	Adult Married in	Adolescent	Child	Reference
Demographic	X	X	X	X	
Medical	X	X	X	X	
Genetic Testing	X	X	X	X	
Life Restriction and Discrimination Questions	X	X	X	X	
Genetic Knowledge	X	X	X	X	
Impact of Event Scale	X	X	X		1
Satisfaction with Decision Instrument	X			X	2
Multidimensional Impact of Cancer Risk Assessment Questionnaire	X	X			3
Beck Anxiety Inventory	X	X			4
Beck Depression Inventory I					5
Wakefield Questionnaire	X	X			6
McMaster Family Assessment Device (General Functioning Subcategory)					7
Kansas Marital Satisfaction Scale	X	X			8
Intolerance of Ambiguity Scale					9
Vulnerability Child Scale				X	10
Scale to Assess Child's Physical and Psychological Health				X	

1. http://consultgerim.org/uploads/File/trythis/try_this_19.pdf
2. <http://umg.umdj.edu/smdm/pdf/16-01-058.pdf>
3. <http://www.primarycarecore.org/pdf/90.pdf>
4. <https://dih.wiki.otago.ac.nz/images/8/80/Beck.pdf>
5. http://www.ibogaine.desk.nl/graphics/3639b1c_23.pdf

6. <http://www.namigc.org/documents/selfreportquestionnaire.pdf>
7. <http://onlinelibrary.wiley.com/doi/10.1111/j.1752-0606.1983.tb01497.x/pdf>
8. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CCUQFjAA&url=http%3A%2F%2Flearners.ncu.edu%2Fsyllabus%2Fdownload_file.asp%3Fsyllabus_rr_id%3D144848&ei=_rZXVLnFGazsATR84HwAw&usg=AFQjCNECi2n275Nu3YH53rCLu3syrG8ldA&sig2=eimgkcLmM31i82ZbUqMEFg
9. <http://www4.ncsu.edu/unity/users/p/padilla/www/435-Leadership/Scale-%20tolerance%20of%20ambiguity.pdf>
10. <http://jpepsy.oxfordjournals.org/content/21/1/89.long>