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ORIGINAL ARTICLE

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Cardiology clinic patient attitudes toward and potential personal utility of genetic testing: Findings from a unique multiracial clinical sample

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Abstract

As more is understood about the hereditary nature of disease risk, the utility of genetic testing within cardiovascular medicine is increasingly being explored. Although testing may afford more personalized risk stratification, there is a paucity of information regarding patient knowledge, attitudes, and beliefs toward genetic testing among cardiology patients. Participants ($n = 530$) recruited primarily from a cardiology clinic filled out a 41-item written questionnaire assessing knowledge, beliefs, and attitudes toward genetic testing, motivators and detractors for considering genetic testing, and perceived likelihood for behavior change after hypothetical genetic testing risk stratification. Path analysis was used to test the hypothetical models predicting the likelihood of getting a genetic test and making behavior changes following genetic testing. The patient population was late-middle-aged (59.0 ± 14.5 years), majority women (61.5%), and about half reported having a bachelor's degree. 58.1% of participants self-identified as White, 25.7% as African American or Black, 6.8% as Spanish, Latino, or Hispanic, 3.0% as Asian or Pacific Islander, and 0.5% as Native American. Gender (being a woman) and more years of education were related to greater knowledge about genetic testing. Racial identity and years of education were related to

beliefs about genetic testing. Beliefs, but not knowledge, were related to more positive attitudes and a higher likelihood of pursuing genetic testing. Positive attitudes were related to greater perceived personal control (PPC). Furthermore, attitudes and PPC were related to higher likelihood of lifestyle change after genetic testing. These results highlight the need to integrate the experiences of racialized communities into education/counseling efforts. Most educational counseling efforts lack a nuanced discussion of social determinants of health or beliefs. In addition to factual information, educational counseling must also address people's beliefs, concerns, and the intersecting experiences and identities, which shape patients' relationships with the evolving landscape of healthcare and personalized medicine.

KEYWORDS
attitudes, beliefs, education, genetic testing

1 | INTRODUCTION

Genetic testing has the potential to provide personalized health risk information to both patients and clinicians. Results of genetic testing can help with medical management and provide anticipatory guidance for long-term life planning. Understanding patients' knowledge, attitudes, and beliefs toward genetic testing can shape pre- and post-genetic testing counseling discussions and may inform if and how patients plan to utilize genetic test results. Existing research on knowledge and attitudes toward genetic testing has shown that older individuals and those with fewer years of formal education generally have more concerns about genetic testing (Calsbeek et al., 2007; Henneman et al., 2013; Khdair et al., 2021). Typical concerns included privacy and potential discrimination (e.g., insurance or healthcare) based on the genetic test results.

In contrast, greater knowledge about genetic testing was shown to be related to more years of formal education and higher household income. Similarly, positive attitudes toward genetic testing have been correlated with individuals who have higher education levels and believe that there is value in genetic testing of hereditary diseases. Interestingly, findings on the relationship between knowledge of, and attitudes toward, genetic testing are mixed, suggesting that having more knowledge about genetic testing is not always related to more positive attitudes toward it (Jallinoja & Aro, 2000). The use of genetic testing in cardiovascular medicine, specifically, is expanding, but many practitioners are not yet well-versed in discussing the utility and 'potential pitfalls' of integrating genetic results into their practices (Musunuru et al., 2020). Therefore, it is critically important that as genetic testing becomes more widely used in cardiac care and available as direct-to-consumer products, clinicians understand their patients' perspectives toward such testing.

To date, most research on patient views toward genetic testing has been conducted using surveys of the general population or patients in a primary care setting. Few studies have investigated the influence of knowledge, attitudes, and beliefs on patient willingness to pursue testing, specifically in a cardiac care clinic. This select patient population likely includes those who already have diagnosed cardiovascular illnesses, putting them at potentially pivotal points of medical care and raising the stakes for lifestyle modifications. The motivation for, and impact of genetic testing results, also likely differs between primary and specialty care patients.

Heart disease is a leading cause of death worldwide and has strong ties to family history (Kolber & Scrimshaw, 2014). Genetic testing can be leveraged to provide more personalized risk stratification of conditions and tailor treatment within the cardiac patient population (Arndt & MacRae, 2014). Therefore, genetic testing may have more utility in a cardiology specialty setting than in the general population. Genetic test results may serve as motivators

What is known about this topic

Greater knowledge about and positive attitudes toward genetic testing have been correlated with individuals who have more years of formal education and higher household income. Findings on the relationship between knowledge of, and attitudes toward, genetic testing are mixed, suggesting that having more knowledge about genetic testing is not always related to more positive attitudes toward it.

What this paper adds to the topic

We found that patient beliefs, but not knowledge about genetic testing, predicted attitudes toward genetic testing. These results highlight the need to integrate the experiences of racialized communities into education and counseling efforts, and acknowledge the exploitative history of genetic testing and its relationship with racialized communities, which, in part, may serve as strong influences and detractors for genetic testing in minoritized patients.

for increased adherence to treatment plans and reinforce patients' commitment to lifestyle changes. Prior studies on behavior change following direct-to-consumer genetic testing demonstrated that approximately one quarter of participants made positive lifestyle changes (Stewart et al., 2018). The sample populations in these studies were not recruited for any specific risk of diseases. However, cardiology patient populations with specific health concerns and possibly strong predisposing family histories of cardiovascular disease may be more likely to initiate and maintain behavioral changes such as improving diet or exercise and managing chronic conditions.

The purpose of this survey-based study was to obtain information on the knowledge, beliefs, and attitudes of cardiology clinic patients toward genetic testing, and to understand how these relate to an interest in pursuing genetic testing or the likelihood for behavioral changes after genetic testing. The results of this study may inform practitioners' decisions to discuss genetic testing in specialty care settings and describe some of the motivations patients have for seeking or avoiding genetic testing. Furthermore, because the sample enrolled is more demographically and socioeconomically representative than previously published results (Michos & Van Spall, 2021; Ortega et al., 2019), these findings may shape the design of specific strategies to address disparities in knowledge, attitudes, and beliefs toward genetic testing.

2 | METHODS

2.1 | Human studies and informed consent

Participants were recruited from cardiology specialty care clinics at a single academic tertiary care hospital. This is a polygenic cardiovascular disease clinic. An on-site geneticist sees patients for potential monogenic disease. For the survey, we focused on patients who were being seen for polygenic disease. Inclusion criteria were age 18 years or older, able to give informed consent, and literate in English. Approval to conduct this human subjects research was obtained by the Rush University Institutional Review Board. All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. All participants provided informed consent for being included in the study.

2.2 | Survey instrument

The final survey consisted of 41 questions (Appendix S1). Seven items assessed patient demographics including age, gender, race/ethnicity, years of education, and annual income level. The remaining questions were mostly 5-point Likert scale type, ranging from 'strongly agree' (1) to 'strongly disagree' (5). Questions aimed at assessing theoretical personal risk thresholds for genetic testing were constructed with percentage intervals (0%, 30%, 50%, 70%, or 90%).

2.2.1 | Survey constructs and items

Questions were designed to assess participants' knowledge, beliefs, and attitudes about genetic testing, interest in genetic testing, and perceived personal control (PPC) and lifestyle changes following hypothetical genetic testing. Some questions were adapted from prior validated questionnaires.

Knowledge

Questions pertaining to the genetic testing knowledge construct centered on knowledge of breast cancer, genetic risks, and confidence in interpreting results.

Attitudes

Questions regarding the attitudes construct evaluated the likelihood of undergoing genetic testing given different contexts and included queries from a genetics survey used by Freedman et al. (2013).

Beliefs

Questions regarding the beliefs construct were adapted from the Research Attitudes Questionnaire (Rubright et al., 2011) (RAQ) and focused on the perceived utility of genetic testing and the confidentiality of results.

Interest in genetic testing

Participants were given the following statement and asked to select 'yes' or 'no': 'I would get genetic testing even if I am currently healthy and do not have symptoms'. Participants were then instructed to select or indicate reasons they may or may not want to get a genetic test. Participants could select multiple provided responses and provide their reasons.

Perceived personal control

The PPC construct included questions on autonomy and self-efficacy after receiving genetic test results and consisted of questions adapted from the PPC questionnaire (McAllister et al., 2012).

Lifestyle changes after genetic testing

Participants were given the following hypothetical scenario: 'Imagine now that you have already gotten genetic testing to see if you have a higher chance of getting a disease. You have received your results'. Participants then indicated if they would be likely to change their diet or exercise depending on the following three scenarios (rated using a Likert scale from 'Strongly Agree' to 'Strongly Disagree'): (1) the results indicate a higher chance of disease, (2) the results do not indicate a higher chance of disease, and (3) the results are inconclusive about disease chance.

2.3 | Data collection

Data were collected from May 2014 through September 2014. Data was entered into a password-protected excel sheet in compliance with IRB requirements. An abstract of these results was presented at a national conference and we decided to review the data to perform further analysis. Although the data were collected a number of years ago, the growing use of direct-to-consumer genetic testing (e.g., 23 and Me, Ancestry.com), continued mass marketing of such services and robust adoption of the general public to obtaining sensitive information (without the guidance of a clinician in a clinical setting) are all important reasons for this data to be analyzed. Further analyses conducted with this data set, utilizing innovative modeling to incorporate social/behavioral factors and their relationship to the outcomes, could be important for future work investigating this type of work through a diversity, equity, and inclusion (DEI) lens.

2.4 | Statistical analysis

Descriptive statistics were performed to evaluate means and standard deviations (SDs). Outlier participants and participants who did not answer at least 50% of survey questions on a scale were removed from our main analysis, resulting in a total of 479 participants. We identified outliers by using multivariate Mahalanobis outlier analysis. We deleted participants case-by-case. Some participants missed all items in a specific scale. In this case, it is recommended to remove the participant instead of imputing missing data. For example, if Case A did not respond for any item of the 'Attitude' scale, we deleted Case A to reduce bias. After deleting these cases. multivariate imputation by chained equations (MICE) via the mice package in R software (Buuren & Groothuis-Oudshoorn, 2011) was then used to impute missing data. Cronbach's alpha was calculated to determine construct reliability. The reliability of the survey constructs was as follows: knowledge, 0.50; beliefs, 0.72; attitude, 0.66; and PPC, 0.87.

Path analysis was used to test the hypothetical models. Path analysis, an extension of multiple regression, is a causal statistical modeling approach to explore magnitude and significance of connections between sets of variables. Path analysis also helps researchers examine whether hypothesized model fits the data by calculating the goodness of fit statistic. Path analysis was performed via the 'Lavaan', and 'SemPlot' packages for R Studio (Epskamp, 2015; Rosseel, 2012; RStudio | Open Source & Professional Software for Data Science Teams, n.d.). Goodness-of-fit (GFI) indices were used to test data-model fit using standard criteria as follows: χ^2 was not significant, the comparative fit index (CFI) and the GFI were greater than 0.90, the standardized root mean square residual (SRMR) did not exceed 0.05, and the root mean square error of approximation (RMSEA) did not exceed 0.08 (Weston et al., 2008).

The path analysis testing the likelihood of participants' receiving genetic testing as the outcome included the following as covariates: age, gender, racial identity, annual income level, years of education, knowledge construct, beliefs construct, and attitudes construct (Figure 1). The first path assessed the relationship between the demographics listed above and the knowledge and beliefs constructs. The second path assessed the relationships among the knowledge, beliefs, and attitudes constructs. The last path assessed the relationship between the attitudes construct and the reported likelihood of receiving genetic testing.

The path analysis testing the likelihood of participants to change their lifestyle after receiving a hypothetical genetic test result as the outcome included demographics (listed above; Figure 2) and the knowledge, beliefs, attitudes, and PPC constructs as covariates. The first path assessed the relationship between demographics and the knowledge and beliefs constructs. The second path assessed the relationship between knowledge, beliefs, attitudes, and PPC constructs. The last path assessed the relationship between attitudes, PPC, and reported likelihood of participants to change their lifestyle after learning their genetic test results.

3 | RESULTS

3.1 | Participant characteristics

The final sample included 530 cardiology clinic patients (Table 1). The average participant age was 59.0 ± 14.5 years old, the majority were women (N = 326, 61.5%), and about half of participants had a bachelor's degree (N = 260, 49.1%). Of the participants, 58.1%

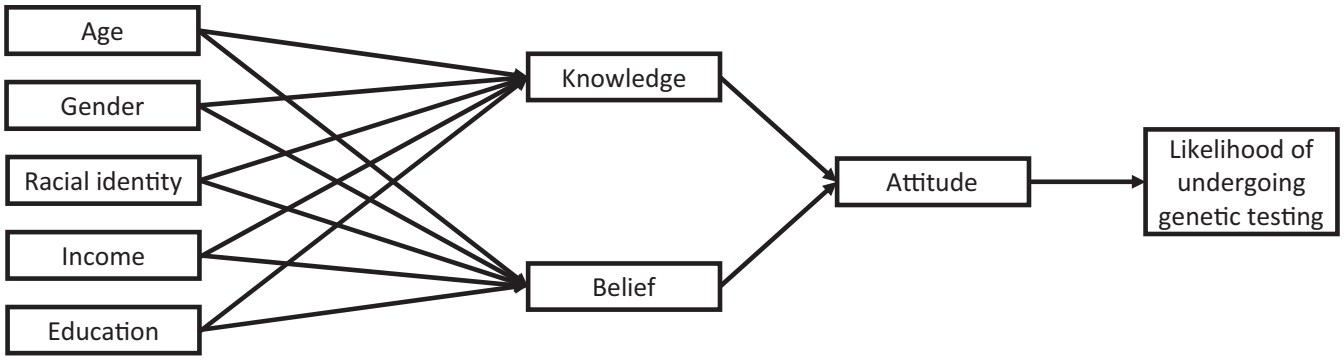

FIGURE 1 Path analysis testing interest in undergoing genetic testing

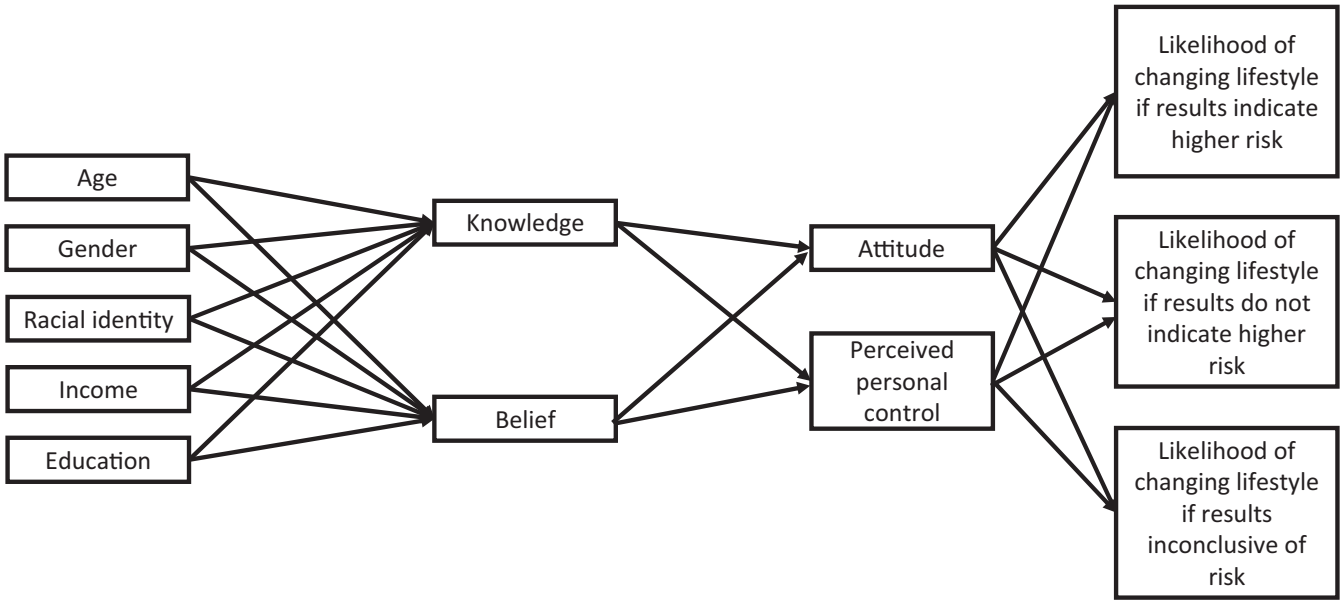

FIGURE 2 Path analysis testing likelihood to change lifestyle after genetic testing

TABLE 1 Sample characteristics

	Overall
Sample size (*n*)	530
Age at survey	59.0 ± 14.5
Gender (% women, *n*)	61.5% (326)
Education (% w/≥Bachelor degree, *n*)	49.1% (260)
Self-identified race (%, *n*)	58.1% (308) White 25.7% (136) African American or Black 6.8% (36) Spanish/Latino/Hispanic 3.0% (16) Asian/Pacific Islander 0.5% (3) Native American
Income level (%, *n*)	17.4% (92) Prefer not to respond 3.2% (17) None 20.6% (109) <$35k 35.3% (187) $35k–$100k 19.6% (104) >$100k
Clinic recruited from (%, *n*)	88.7% (470) Rush Cardiology 9.1% (48) Rush Oak Park Cardiology 2.1% (11) Rush OB/Gyn
First time seeing this clinic doctor (% yes, *n*)	21.7% (115)
Have heard of genetic testing (% yes, *n*)	83.4% (442)
Chance of developing disease that is high enough to want genetic testing	18.7% (99) 10% chance 22.5% (119) 30% chance 30.4% (161) 50% chance 13.8% (73) 70% chance 7.5% (40) 90% chance

self-identified as white; 25.7% as African American or Black; 6.8% as Spanish, Latino, or Hispanic; 3.0% as Asian or Pacific Islander; and 0.5% as Native American. In terms of annual income, 20.6% of participants reported an annual income level of <$35k, 35.3% reported an income level of $35k–$100k, and 19.6% reported an income level of >$100k. Most participants had seen the doctor at this clinic before (N = 415, 78.3%) and had heard of genetic testing (N = 442, 83.4%). Most also demonstrated an openness to genetic testing; for example, when asked what percent chance of developing a disease would prompt patients to seek genetic testing, 41.2% (N = 218) reported a 10%–30% risk would be sufficient, 30.4% (N = 161) reported a 50% risk would be sufficient, and 21.3% (N = 113) reported a 70%–90% would be sufficient.

3.2 | Interest in genetic testing model fits and predictors of likelihood of undergoing genetic testing

3.2.1 | Interest in genetic testing

Of the participants, 65.1% (N = 345) reported that they would undergo genetic testing even if they were currently healthy and did not have symptoms (Table 2). Reasons included wanting to know their personal health information (79.1%), the usefulness of the information to improve their health (75.1%), and having a right to information about themselves (44.6%; responses were not mutually exclusive). Open-ended responses included wanting to help their families (N = 27, 7.8%), having a family history of illness (N = 5, 1.4%), desiring to help science and/or others (N = 4, 1.2%), and desiring to prepare themselves for the future (N = 2, 0.6%). A sizable minority (N = 166, 31.3%) of participants replied they would not be interested in genetic testing if they were healthy. Greater than

TABLE 2 Reasons for wanting or not wanting genetic testing

	Overall
Sample size	530
Would get genetic testing even if currently healthy and do not have symptoms (% yes, *n*)	65.1% (345) Reason for getting test (can choose multiple, out of *n* = 345): • Want to know health information about self: 79.1% (273) • Can use the information to improve health: 75.1% (259) • Have right to information about self: 44.6% (154) • Other: To help family: 7.8% (27) Have family history of illness: 1.4% (5) Want to help science/others: 1.2% (4) Prepare self for future: 0.6% (2) Reason for not getting test (can choose multiple, out of *n* = 166): • Don't think information is important: 11.4% (19) • Don't think can improve health with information: 24.1% (40) • Would only get tested if symptomatic: 54.2% (90) • Other: Older age: 6.0% (10) Need more information: 4.2% (7) Don't care to know: 1.8% (3) Test may be unreliable: 3.0% (5) Concern about discrimination (esp. insurance): 3.6% (6) Learning result may distress me: 1.8% (3) Don't have family history/family with which to share results: 2.4% (4) Religious beliefs: 0.6% (1)

half would only get tested if they became symptomatic (N = 90, 54.2%), believing their health would not be improved with such information (N = 40, 24.1%), and thinking such information was unimportant (N = 19, 11.4%; answers were not mutually exclusive). Additional reasons for opting out of hypothetical genetic testing included old age (N = 10, 6.0%), needing more information (N = 7, 4.2%), not caring to know the results (N = 3, 1.8%), test reliability/validity concerns (N = 5, 3.0%), concern about discrimination (N = 6, 3.6%), distress about potential results (N = 3, 1.8%), no family history or family to share results with (N = 4, 2.4%), and religious beliefs (N = 1, 0.6%).

3.2.2 | Model fits

In the model predicting the likelihood of participants to undergo genetic testing, the results of the path analysis revealed an excellent model fit: $\chi^2(17, N = 479) = 23.09$, $p = .15$, CFI = 0.99; GFI = 0.99, SRMR = 0.03; and RMSEA (95% CI) = 0.03 (0.00–0.05). The results indicated the model fit data adequately.

3.2.3 | Predictors of likelihood to undergo genetic testing

Of the path from demographics regarding the knowledge and beliefs constructs (Figure 1), higher level of education was related to both more genetic testing knowledge (b: −0.20, $p < .05$) and more positive beliefs about genetic testing (b: −0.29, $p < .05$). Women were found to have more genetic testing knowledge (b: −0.98, $p < .05$). Furthermore, participant identification as African American or Black was related to more negative beliefs about genetic testing (b: 1.08, $p < .05$).

Regarding the path from knowledge and beliefs to the attitude construct, more positive beliefs about genetic testing were related to more positive genetic testing attitudes (b: 0.49, $p < .05$). In the final path, more positive attitudes regarding genetic testing were related to the higher likelihood of undergoing genetic testing (b: −0.06, $p < .05$).

3.3 | Likelihood to change lifestyle after genetic testing model fits and predictors of likelihood

3.3.1 | Likelihood to change lifestyle after genetic testing

Participants indicated agreement as to how likely they would be to change their diet and exercise after learning three different hypothetical risk results. If the results indicated a higher change of disease, 88.5% of participants agreed they would be likely to change their diet or exercise. If the results did not indicate a higher chance of disease, 50% of participants agreed they would be likely to change their diet or exercise. If the results were inconclusive, 59.7% agreed they would be likely to change their diet or exercise (Table 3).

TABLE 3 Likelihood of changing diet and exercise after learning genetic results for disease that can be helped through lifestyle modifications

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Results indicate higher chance (%, *n*)	46.8% (248)	41.7% (221)	6.8% (36)	0	0
Results do not indicate higher chance (%, *n*)	15.5% (82)	34.5% (183)	32.5% (172)	10.9% (58)	0.9% (5)
Results inconclusive of chance (%, *n*)	20.8% (110)	38.9% (206)	29.8% (158)	4.9% (26)	0.8% (4)

3.3.2 | Model fits

In the first model predicting changes in lifestyle in the case of a higher chance of disease, the results of the path analysis revealed a significant chi-squared statistic: $\chi^2(17, N = 479) = 57.47$, $p < .05$; CFI = 0.94; GFI = 0.96, SRMR = 0.05; and RMSEA (95% CI) = 0.07 (0.05–0.09). In the second model predicting changes in lifestyle in the case of no higher chance of disease, the results indicated the model fit the data adequately. The results of the path analysis revealed a significant chi-squared: $\chi^2(17, N = 479) = 59.96$, $p < .05$; CFI = 0.93; GFI = 0.96, SRMR = 0.04; and RMSEA (95% CI) = 0.06 (0.05–0.08). The results again indicated that the model fit the data adequately. In the third model predicting changes in lifestyle in the case of inconclusive results, the results indicated the model fit the data adequately. The results of the path analysis revealed a significant chi-squared: $\chi^2(17, N = 479) = 57.08$, $p < .05$; CFI = 0.93; GFI = 0.96, SRMR = 0.05; and RMSEA (95% CI) = 0.07 (0.05–0.09).

3.3.3 | Predictors of likelihood to change lifestyle after receiving hypothetical genetic test results

Of the path from demographics to knowledge and beliefs (Figure 2), woman gender (*b*: −0.8, $p < .05$) and higher levels of education (*b*: −0.23, $p < .05$) were related to increased knowledge about genetic testing. Higher levels of education were also related to more positive beliefs about genetic testing (*b*: −0.26, $p < .05$), while African American or Black racial identity was related to increased negative beliefs (*b*: 1.43, $p < .05$). More positive beliefs were related to more positive attitudes (*b*: 0.47, $p < .05$), which in turn were related to more PPC (*b*: 0.42, $p < .05$). Finally, more PPC was related to higher likelihood of participants changing their lifestyle after genetic testing, regardless of the results (higher risk, −*b*: 0.04, $p < .05$; no higher risk, −*b*: 0.06, $p < .05$; inconclusive risk, −*b*: 0.07, $p < .05$). More positive attitudes about genetic testing were related to a higher likelihood of participants changing their lifestyle if they were or were not at higher risk for disease (*b*: 0.06, $p < .05$; *b*: 0.03, $p < .05$), but not if the risk level was inconclusive.

4 | DISCUSSION

In this sample of 530 cardiac clinic patients, most survey participants were receptive to genetic testing as a means to understand their personal disease risk. When asked what percentage risk for developing a disease was high enough to prompt them to want to undergo genetic testing, many participants (71.6%) reported a 10%–50% chance, suggesting results do not need to be conclusive of disease development for patients to want to learn about their risk. Participants indicating they would not undergo genetic testing if they were currently healthy and non-symptomatic ($N = 166$, 31.3%) reported eight free-response reasons, compared to the four free-response reasons reported by those who indicated they would undergo testing. It is curious to note the higher number of reasons and more variability in endorsement provided by people not wanting genetic testing. For those amenable to testing, reasons provided were relatively consistent, compared to reasons provided by those disinclined to undergo testing. These findings suggest there may be greater and more varied reasons as to why some patients might *not* want genetic testing compared to patients amenable to testing.

Importantly, we found that common demographic and socioeconomic factors of racial identity and years of formal education, but not income level, were related to beliefs about genetic testing. In turn, we found that patient beliefs, but not knowledge about genetic testing, predicted attitudes toward genetic testing. These results highlight the need to integrate the experiences of racialized communities into education and counseling efforts, and acknowledge the exploitative history of genetic testing and its relationship with racialized communities, which, in part, may serve as strong influences and detractors for genetic testing in minoritized patients. Most educational counseling efforts have largely been designed for white participants and include mostly facts (e.g., numerical information, 'nuts and bolts' of what the test results mean) but lack a nuanced discussion of the social determinants of health or beliefs. Our results highlight the important point that fact-driven information alone may not be meaningful in influencing attitudes or decisions about pursuing genetic testing. In addition to factual information, educational counseling must also address people's beliefs, concerns, and intersecting experiences and identities that shape their relationships with the healthcare system. This may require acknowledgment of the institutional roots of mistrust and active, collaborative work by institutions to rebuild trust with communities.

In the analysis predicting participants' likelihood to make changes to their diet or exercise after receiving genetic test results, we similarly found that racial identity and years of formal education predicted beliefs about genetic testing. Furthermore, beliefs predicted both genetic testing attitudes and perceptions about one's ability to control outcomes (i.e., PPC) after learning test results, such that more positive beliefs were related to more positive

attitudes and PPC. Increased PPC was related to a greater likelihood of making lifestyle changes regardless of the genetic testing result scenario (disease risk: higher, inconclusive, not at risk). Similarly, more positive attitudes were related to a higher likelihood of participants making lifestyle modifications regardless of whether genetic testing results suggested a higher risk of developing disease. These results are concordant with self-determination theory (SDT), a theoretical framework that has been used to understand and test hypotheses about mechanisms underlying behavioral change (Ntoumanis et al., 2021; Patrick & Williams, 2012; Teixeira et al., 2012). SDT emphasizes the importance of self-efficacy and autonomy in actualizing behavioral change (Teixeira et al., 2012), including changes to physical activity or eating habits.

Again, these results support the importance of addressing patient beliefs regarding genetic testing. Understanding these factors can then improve their attitudes and PPC, making them more likely to institute lifestyle changes. Ultimately, these analyses highlighted that participants most likely to undergo genetic testing and make changes to exercise or diet habits after genetic testing were those who believed genetic testing was useful and felt the results would be actionable. Empowering individuals with genetic test results requires bolstering positive beliefs toward genetic testing. Impacting beliefs first and most importantly begins with the healthcare and biomedical fields building trust with racialized communities (Christopher et al., 2008). This may be done through community-based activities where healthcare providers or researchers build relationships with community members first before discussing genetic testing. It is imperative that in interactions with racialized communities, healthcare providers/researchers acknowledge the painful history these communities have with the biomedical field. At the clinic and in the community, healthcare providers/researchers should prepare to have ongoing conversations with patients and adapt the information they share based on feedback. For example, this could include providing more information on the personal utility and confidentiality of genetic test results. It is important to note that different ethnic and racial groups have different belief systems and historical relationships with healthcare and research. As such, engagement with different groups will require different approaches and materials will need to be amended accordingly.

This study has important strengths. First, most cardiology research is conducted on white men. This study reflects the perspectives of a sample made up largely of women and was more racially and economically representative than previously published findings (Michos & Van Spall, 2021; Ortega et al., 2019). This may improve the generalizability of the results presented. Second, genetic testing and educational counseling are relevant to cardiac clinic patients and risk assessment in various cancers, dementia, and other neurological disorders. The conclusion of the importance of ensuring culturally informed and relevant educational counseling extends to cardiac clinics and beyond.

Some limitations of the sample include a restricted age range (59.0 ± 14.5 years) and years of education (49% have a bachelor's degree), reducing the generalizability of the results. Another limitation of this study is that the convenience sample may be biased in that all participants were patients in a cardiac clinic and likely more trusting of the particular clinic from which they were recruited. It is unclear if the attitudes assessed in this clinic carry across all healthcare settings in which participants obtain care.

Lastly, the knowledge factor did not have good reliability (alpha: 0.50). Potentially, a knowledge factor with better reliability may have had a significant relationship with attitudes and PPC. Many of the questions (4/7) developed for the knowledge factor focused on genetic risk factors for breast cancer. Future studies may include updated questions for the knowledge factor and assessment of different populations, including but not limited to memory clinics, longitudinal research studies, and community-based research.

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AUTHOR CONTRIBUTIONS

Ms. Claire Erickson contributed to the paper in the following ways: conceptualization, formal analysis, visualization, writing original draft, writing review and editing. Dr. Lindsay Clark contributed to the paper in the following ways: conceptualization, formal analysis, supervision, writing review and editing. Dr. Emre Umucu contributed to the paper in the following ways: conceptualization, data curation, formal analysis, methodology, writing review and editing. Dr. Nhi Vo contributed to the paper in the following ways: conceptualization, data curation, investigation, project administration, writing review and editing. Dr. Annabelle Santos Volgman contributed to the paper in the following ways: conceptualization, project administration, writing review and editing. Dr. Nathaniel Chin contributed to the paper in the following ways: conceptualization, writing review and editing. Dr. Fred Ketchum contributed to the paper in the following ways: conceptualization, methodology, writing review and editing. Dr. Carolyn Jones contributed to the paper in the following ways: conceptualization, methodology, writing review and editing. Dr. Carey Gleason contributed to the paper in the following ways: conceptualization, formal analysis, methodology, writing review and editing. Dr. Neelum Aggarwal contributed to the paper in the following ways: conceptualization, data curation, methodology, project administration, resources, supervision, writing review and editing. All the authors give approval for this manuscript to be published and agree to be accountable for all aspects of the work in ensuring its accuracy and integrity.

COMPLIANCE WITH ETHICAL STANDARDS

CONFLICT OF INTEREST

Ms. Claire Erickson and Drs. Lindsay Clark, Emre Umucu, Nhi Vo, Annabelle Santos Volgman, Nathaniel Chin, Fred Ketchum, Carolyn

Jones, Carey Gleason, Neelum T. Aggarwal declare they have no relevant conflicts of interest to report.

HUMAN STUDIES AND INFORMED CONSENT

Approval to conduct this human subjects research was obtained by the Rush University Institutional Review Board. All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. All participants provided informed consent for being included in the study.

ANIMAL STUDIES

No non-human animal studies were carried out by the authors for this article.

DATA SHARING AND DATA ACCESSIBILITY

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

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