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ORIGINAL RESEARCH

Practitioners' Confidence and Desires for Education in Cardiovascular and Sudden Cardiac Death Genetics

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BACKGROUND: Educating cardiologists and health care professionals about cardiovascular genetics and genetic testing is essential to improving diagnosis and management of patients with inherited cardiomyopathies and arrhythmias and those at higher risk for sudden cardiac death. The aim of this study was to understand cardiology and electrophysiology practitioners' current practices, confidence, and knowledge surrounding genetic testing in cardiology and desired topics for an educational program.

METHODS AND RESULTS: A one-time survey was administered through purposive email solicitation to 131 cardiology practitioners in the United States. Of these, 107 self-identified as nongenetic practitioners. Over three quarters of nongenetic practitioners reported that they refer patients to genetic providers to discuss cardiovascular genetic tests (n=82; 76.6%). More than half of nongenetic practitioners reported that they were not confident about the types of cardiovascular genetic testing available (n=60; 56%) and/or in ordering appropriate cardiovascular genetic tests (n=66; 62%). In addition, 45% (n=22) of nongenetic practitioners did not feel confident making cardiology treatment recommendations based on genetic test results. Among all providers, the most desired topics for an educational program were risk assessment (94%) and management of inherited cardiac conditions based on guidelines (91%).

CONCLUSIONS: This study emphasizes the importance of access to genetics services in the cardiology field and the need for addressing the identified deficit in confidence and knowledge about cardiogenetics and genetic testing among nongenetic providers. Additional research is needed, including more practitioners from underserved areas.

Key Words: cardiogenomics ■ cardiology ■ continuing medical education ■ genetic testing

Monogenic diseases of heart rhythm and muscle, such as cardiomyopathies and arrhythmias, affect ≈1 in 500 people, presenting a clinical disease in both children and adults.[1,2] Genetic testing yields vary for inherited cardiomyopathies and arrhythmia syndromes, ranging from 20% to 50% in family dilated cardiomyopathy to 75% in long-QT syndrome.[3–10] Genetic testing for inherited cardiac conditions is useful for the clinical management of patients and at-risk family members.[11–13] Identifying those at increased risk for disease allows for earlier detection and interventions, including lifestyle modifications, drugs to slow disease progression or to prevent thromboembolism, and procedures, drugs, or devices to reduce the risk of sudden cardiac death (SCD).

Despite the benefits of genetic testing, cardiac providers may be unprepared to implement genetic testing in clinical care.[14,15] In cardiology and other specialties,

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CLINICAL PERSPECTIVE

What Is New?

- We asked practicing cardiology practitioners about their confidence with regard to the application of cardiogenomics in practice and preferred topics for continuing medical education in cardiogenomics.

What Are the Clinical Implications?

- Many cardiology practitioners are not confident about ordering appropriate cardiogenomics tests and making treatment recommendations based on genetic tests and desire additional education in risk assessment incorporating genomics and management of inherited cardiac conditions based on guidelines.

Nonstandard Abbreviations and Acronyms

SCD	sudden cardiac death

nongenetics health professionals have been unable to keep up with the advancements in genomics.[16–20] This has been attributed partly to lack of contemporary genetic knowledge and lack of confidence in integrating genetic information and technologies into patient education, management, and referral.[18,19] The complexity of current cardiovascular genetic evaluation and testing has led to published guidelines recommending evaluation in specialized centers whenever possible to facilitate access to multidisciplinary teams that include cardiovascular clinicians, geneticists, and genetic counselors.[11,21] In 2016, the American Heart Association recommended that every cardiovascular clinician should have the basic skill set to suspect a genetic condition, a basic understanding of genetic testing technology and results interpretation, and the ability to recognize when a genetic diagnosis influences medical and surgical care of patients.[15] Consequently, educating cardiologists and electrophysiology practitioners about cardiovascular genetics and genetic testing is critical to improving patient screening, risk assessment, diagnosis, and clinical care for cardiology patients.

Previous studies have demonstrated that educational programs grounded in evidence-based principles of adult learning and best-practice principles of backward design can have a significant impact on health care providers' performance.[22–26] Principles of adult learning include using existing knowledge as the foundation for new knowledge and integration into current practices. Therefore, this study aimed to ascertain cardiology and electrophysiology practitioners' (1) confidence in cardiomyopathy and arrhythmia genetic testing, (2) current cardiomyopathy and arrhythmia genetic testing ordering practices, (3) knowledge of cardiovascular genetics as it relates to current cardiovascular management guidelines, and (4) desired topics for an educational program for this population of medical professionals.

METHODS

A one-time survey was administered to providers who care directly for children and adults affected with and/or at risk for heritable cardiovascular disease and who evaluate families with a history of SCD. The study was approved by Northwestern University's Institutional Review Board (STU00210365), and subjects provided informed consent.

Survey Design

Question design was driven by previous qualitative interviews and pilot data obtained from 7 practicing cardiologists.[27] Study data were collected and managed using Research Electronic Data Capture hosted at Northwestern University.[28,29]

The survey consisted of 5 main sections: (1) current practices around genetic testing for inherited cardiac conditions (focused on inherited cardiomyopathies and arrhythmia syndromes), (2) practitioners' confidence in their knowledge of cardiovascular genetic testing, (3) practical knowledge based on current practice guidelines for management of patients with ventricular arrhythmias and the prevention of SCD,[12] (4) preferences for continuing medical education topics, and (5) demographics. Assessment of current practices included questions about access to genetics professional(s), frequency of referral for genetic evaluation, performance, and discussion of genetic testing for inherited cardiac conditions, as well as practitioners' reported barriers and motivations to implementing genetic testing into their practice. Assessment of confidence in knowledge included topics related to understanding of genetics information, risk assessment for inherited cardiac conditions, genetic test ordering, genetic test report interpretation, and management of patients based on genetic test results. Multiple-choice questions were used to assess demographic information and practice patterns. Knowledge assessment was based on a board-style vignette and question format. Likert scales were used to assess the respondent's confidence in each response. The full survey is provided in Data S1.

Participants and Recruitment

Recruitment took place between January 21 and April 5, 2021. To be eligible for inclusion, participants were required to self-identify as a licensed physician,

nurse, physician assistant, or advanced practice nurse (stated as "licensed MD, DO, PA, RN, or APRN") and provide direct patient care in the United States. Genetic counselors were excluded from this study. In addition, participants were asked to self-identify as a genetics professional in the field of cardiology (medical geneticist or a physician with genetic expertise) or nongenetics professional in the field of cardiology. This allowed the comparison of current practices, confidence, and practical knowledge between these 2 groups.

Participants were recruited from across the United States via email. Using a purposive approach, key contacts from health care organizations (Northwestern Medicine, Sanford Health, and several pediatric research hospitals), professional organizations (the American Heart Association Strategically Focused Research Networks, the National Society of Genetic Counselors Cardiovascular Genetics Special Interest Group, the Pediatric & Congenital Electrophysiology Society, and local chapters of American College of Cardiology nursing groups), and the advocacy organization Project ADAM were leveraged to disseminate the email. Leaders in all the organizations listed were contacted by email and asked to disseminate the email as widely as possible. Email recipients were also encouraged to forward the email onto other potentially interested and eligible practitioners in a snowball recruitment approach.

Statistical Analysis

Confidence in the respondents' knowledge of genetic testing for inherited cardiac conditions was evaluated using 13 "*I feel confident in…*" statements. Participants responded using a 5-point Likert scale (from strongly disagree to strongly agree). A mean score for each statement was calculated and used to rank these from highest to lowest confidence. An overall confidence score was calculated as the sum of all the 13 confidence responses for each participant. Similarly, an overall knowledge score was calculated for each participant as the number of correct responses to all knowledge questions. Continuous variables were compared using *t*-tests. Categorical variables were compared using a χ^2 test. A 2-sided $P<0.005$ was considered significant to adjust partially for the number of questions asked on the survey. R version 4.0.1 was used for statistical analyses.[30] Data are available on request.

RESULTS

Demographics

A total of 158 individuals agreed to participate; 26 participants were excluded because they did not meet inclusion criteria or did not complete the survey after providing consent, resulting in 131 responses for inclusion in the study. Most survey respondents were physicians (77%; n=101), White race (76.3%; n=100), and non-Hispanic ethnicity (95.4%; n=125), and had been practicing medicine for 10 to 15 years (17.6%; n=23) or >15 years (42%; n=55). Sex identity was almost equally balanced, with 62 women (47.3%) and 65 men (49.6%). The geographic region and work setting of participants was skewed to university medical centers (81.7%; n=107), primarily located in urban regions (80.9%; n=106). The Table provides demographics for study participants, stratified into those who self-identified as cardiac genetics providers (hereafter labeled genetics professionals: 17%; n=23) and those who did not (82%; n=108).

Current Practices

Figure 1 summarizes the frequency with which practitioners engage patients and colleagues about cardiovascular genetics. Most genetics and nongenetics professionals both referred patients to genetics once a month (43.5% [n=10] of genetics professionals; 45.8% [n=49] of nongenetics professionals). As expected, those who self-identified as genetics professionals discussed genetic testing more frequently than those who did not identify as genetics professionals (once per week or more for genetic professionals [78.3%; n=18] compared with only once a month [48.6%; n=52] for nongenetics professionals). Self-identified genetics professionals also reported self-ordering genetic tests for their patients more often (ie, once a week or more [60.8%; n=14]), compared with nongenetics professionals (ie, once a month or less [84.1%; n=90]). These differences were statistically significant. In addition, 10% (n=11) of nongenetics professionals never discussed genetic testing, 14% (n=15) never referred patients to genetics, and 8% (n=9) never had genetic testing performed for their patients.

Most nongenetic professionals preferred to refer their patients to genetics for discussing genetic testing options (76.6%; n=82), implications of positive results (71%; n=76), and implications of uncertain results (86%; n=92), and for discussing implications to family members (78.5%; n=84). In all cases, these were statistically significantly different than the preferences expressed by genetic professionals (Figure 2).

Most participants reported access to genetic services; 90% (n=119) reported having access to a genetics professional to whom they can refer patients, and 85% (n=112) reported having a genetics professional with whom they can consult about clinical care for issues relating to inherited cardiac conditions. Although we are hesitant to conclude that 85% to 90% of cardiology professionals in the United States have access

Table 1. Characteristics of the Study Population by Genetics Expertise

Characteristics	Genetics professional (N=23)	Nongenetics professional (N=107)	Overall (N=131)
Educational background			
Adult cardiologist	13 (56.5)	36 (33.6)	49 (37.4)
Pediatric cardiologist	10 (43.5)	29 (27.1)	39 (29.8)
Advanced Practice Nurse	0 (0)	14 (13.1)	14 (10.7)
Fellow	0 (0)	11 (10.3)	12 (9.2)
Other	0 (0)	2 (1.9)	2 (1.5)
Physician Assistant	0 (0)	3 (2.8)	3 (2.3)
Registered nurse	0 (0)	10 (9.3)	10 (7.6)
Resident	0 (0)	1 (0.9)	1 (0.8)
Time practicing, y			
Residency	0 (0)	3 (2.8)	3 (2.3)
<5	5 (21.7)	24 (22.4)	30 (22.9)
5–10	2 (8.7)	17 (15.9)	19 (14.5)
10–15	5 (21.7)	18 (16.8)	23 (17.6)
>15	11 (47.8)	44 (41.1)	55 (42.0)
Geographic region			
Urban	19 (82.6)	86 (80.4)	106 (80.9)
Suburban	4 (17.4)	19 (17.8)	23 (17.6)
Rural	0 (0)	1 (0.9)	1 (0.8)
Work setting			
Private group practice	2 (8.7)	2 (1.9)	4 (3.1)
Private solo practice	0 (0)	1 (0.9)	1 (0.8)
University medical center	18 (78.3)	88 (82.2)	107 (81.7)
Private hospital	0 (0)	3 (2.8)	3 (2.3)
Public hospital	3 (13.0)	11 (10.3)	14 (10.7)
Sex identity			
Men	14 (60.9)	50 (46.7)	65 (49.6)
Women	9 (39.1)	53 (49.5)	62 (47.3)
Prefer not to disclose	0 (0)	2 (1.9)	2 (1.5)
Hispanic ethnicity			
Hispanic	0 (0)	1 (0.9)	1 (0.8)
Non-Hispanic	23 (100)	101 (94.4)	125 (95.4)
Race			
Asian (eg, East/South/Southeast)	6 (26.1)	16 (15.0)	22 (16.8)
Mixed	1 (4.3)	3 (2.8)	4 (3.1)
White	15 (65.2)	84 (78.5)	100 (76.3)
Other	1 (4.3)	3 (2.8)	4 (3.1)

Data are given as number (percentage). Some categories do not sum to 100% because of missing data.

to a genetics professional to whom they can refer patients or consult about clinical care, these data provide context about the type of providers who responded to the survey.

Barriers and Motivators to Incorporating Genetic Testing of Inherited Cardiac Conditions Into Practice

Thirty-six participants reported experiencing barriers/frustrations in implementing genetic testing, with the 3 most reported barriers being cost of genetic testing (too costly or not reimbursable) (61.1%; n=22), theoretic risk of increasing insurance discrimination (58.3%; n=21), and requiring more education for implementing genetic testing into their practice (58.3%; n=21). Other reported barriers included insurance coverage (prior authorizations and difficulty of getting letters of medical necessity) and limited availability of genetics providers (half-time coverage, overbooked, or understaffed). In addition, "literature changes quickly and is often not intuitive" was also specifically reported as a barrier.

Most participants (94.7%; n=124) responded that they would be motivated to incorporate more genetic testing into practice if there was evidence in the medical literature that their patient population was at risk for carrying a pathogenic variant in genes that increase risk for heart disease/SCD. In addition, most (91.5%; n=120) reported that evidence-based professional society guidelines were a motivator to incorporate more genetic testing into practice. Other reported motivators included genetic testing reference guides and online resources for families.

Confidence in Knowledge About Genetics and Genetic Testing in Cardiology

Figure 3 displays providers' confidence in their knowledge of cardiovascular genetics and genetic testing. Providers with genetics expertise had a higher overall confidence score than nongenetics professionals (55.6 versus 40.7; $P<0.001$). With the exception of confidence to "identify the best person to initiate genetic testing," confidence scores for all questions differed statistically significantly ($P<0.005$) between genetics and nongenetic professionals. Both genetics and nongenetics professionals felt most confident identifying the best person in the family to initiate genetic testing (96% of genetics professionals [n=22] felt confident, agreed or strongly agreed to feeling confident; 82% of nongenetics professionals [n=88] felt confident, agreed or strongly agreed to feeling confident), followed by knowing when to refer patients to genetics (96% of genetics professionals [n=22] felt confident; 72% of nongenetics professionals [n=77] felt confident) and identifying clinical situations in which genetic testing is indicated (100% of genetics professionals [n=23] felt confident; 65% of nongenetics professionals [n=70] felt confident). However, topics for which health care providers reported the least confidence differed between genetics and nongenetics professionals. Nongenetics

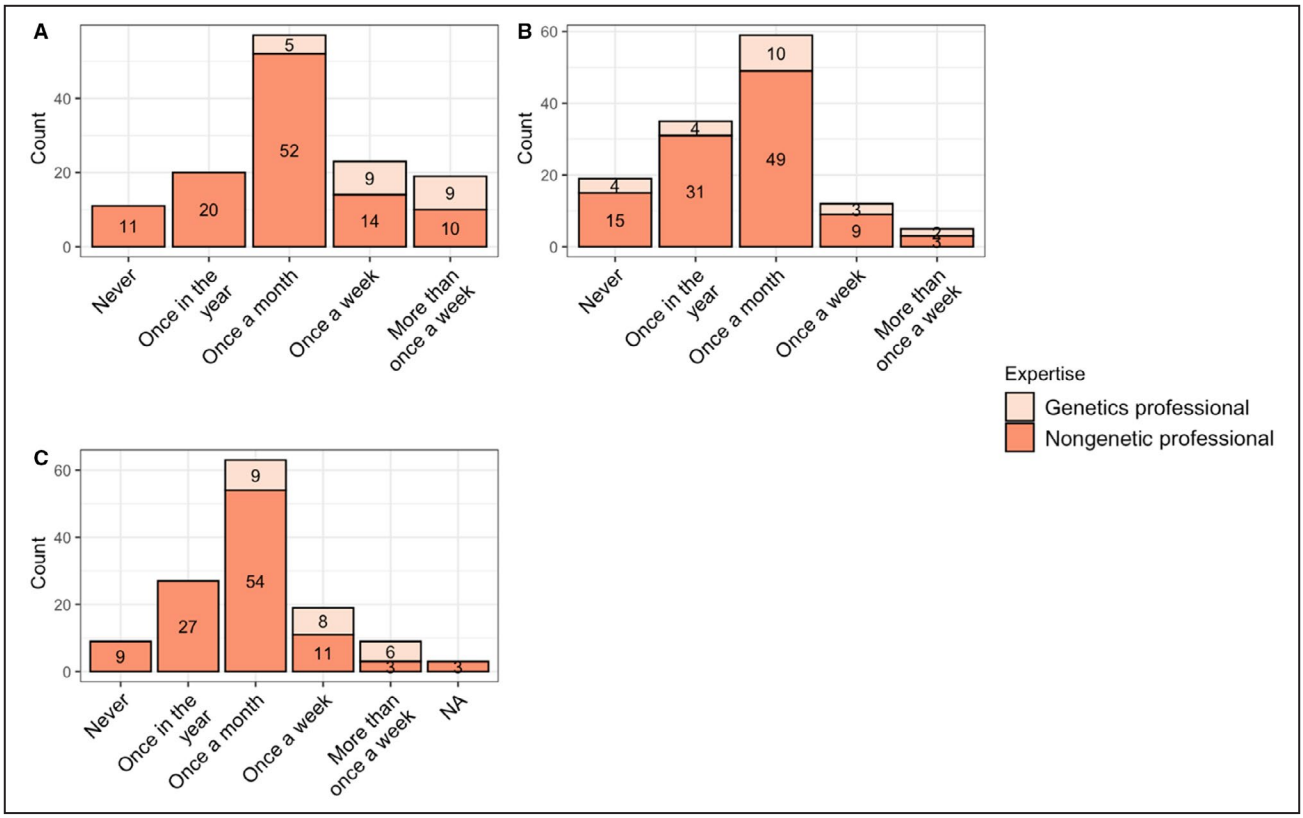

Figure 1. Frequency with which genetics and nongenetics professionals discuss, refer, and perform genetic testing for their patients.

A, Responses to the question, "How often did you discuss genetic testing for inherited cardiac conditions with patients in 2019?" **B**, Responses to the question, "How often did you refer said patients to genetics?" **C**, Responses to the question, "How often are genetic tests performed for your patients?" For all 4 panels, responses between genetics and nongenetics professionals were statistically significantly different ($P<0.005$). NA indicates not applicable.

professionals are least confident in their knowledge about genetic testing, including interpreting a genetic test result (43% [n=46] did not feel confident, disagreed or strongly disagreed to feeling confident), knowing the types of genetic testing available (56% [n=60] did not feel confident), and identifying the appropriate genetic test to order (62% [n=66] did not feel confident). In addition, 45% (n=48) of nongenetics professionals do not feel confident making treatment recommendations based on genetic test results. In contrast, genetic professionals are mostly confident in most genetic-related tasks. Genetics professionals reported the least confidence in providing psychosocial support to patients.

Clinical Knowledge of Genetic Testing in Cardiology Based on Practice Guidelines

Providers were evaluated on their practical knowledge of genetic testing in cardiology with questions based on current practice guidelines.[12] Most (93.9%; n=123) correctly identified a clinical situation in which genetic testing for arrhythmia syndromes was warranted. Similarly, 91.6% (n=120) correctly identified the most clearly affected family member as the best person to initiate genetic testing.

Desired Topics for an Educational Program

Among all providers, the most desired topics for a cardiogenetics educational program were how to conduct a risk assessment for inherited cardiac conditions (94%; n=120) and management of inherited cardiac conditions based on guidelines (91%; n=117) (Figure 4). In addition, topics on genetic testing, including both interpreting genetic test results (78%; n=100) and ordering genetic tests (70%; n=89), were also highly desired by most providers. There was no significant difference in desired topics between nongenetic and self-identified genetic providers, and so pooled data are presented in Figure 4.

DISCUSSION

This study assessed cardiology practitioners' current practices, confidence, and knowledge surrounding cardiovascular genetics and genetic testing in a US-based cohort. Our findings reveal 3 overarching themes: (1) nongenetic professionals report deficits in

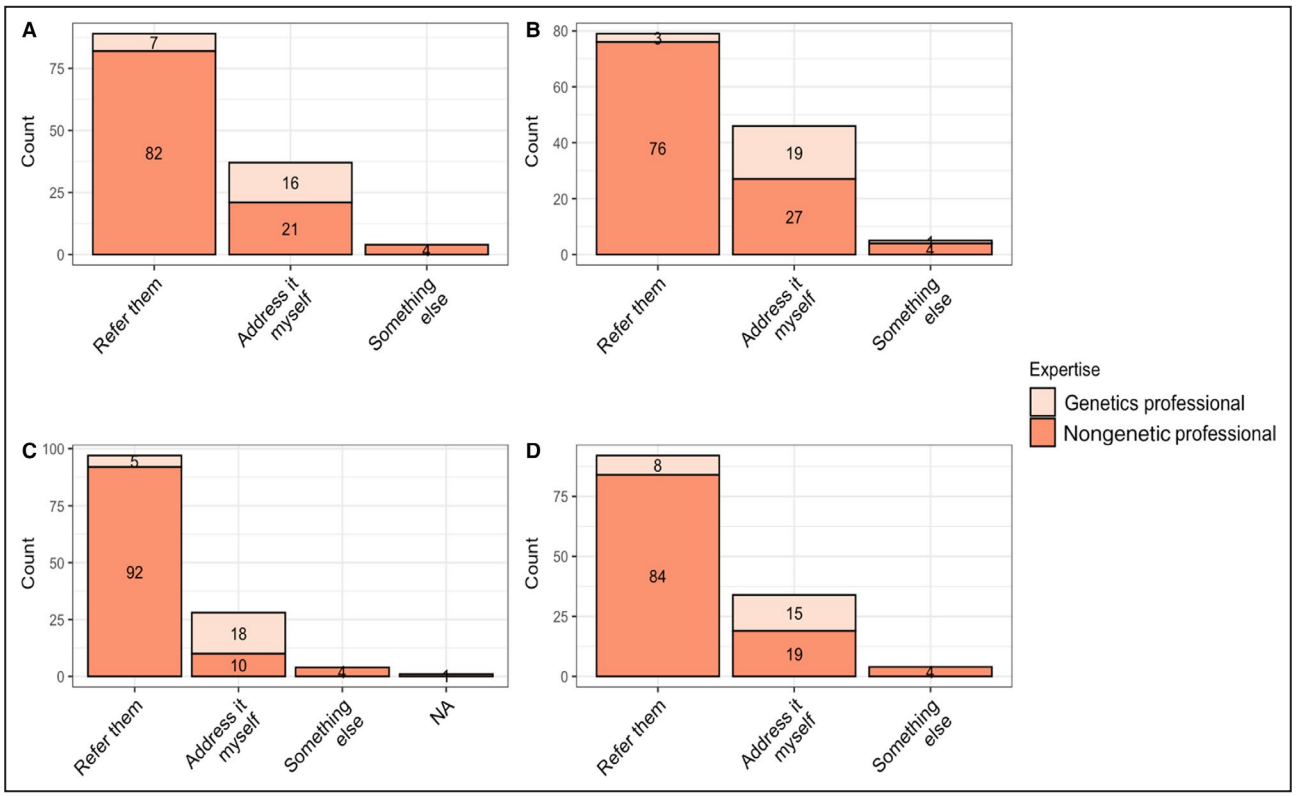

Figure 2. Preferences for discussions about genetic testing options.
Providers were asked how they handled each of the following clinical scenarios: **A**, Discussing options for genetic testing. **B**, Discussing the implications of a positive result with a patient. **C**, Discussing the implications of variant of uncertain significance with a patient. **D**, Discussing the implications of genetic testing results for family members. For all 4 panels, responses between genetics and nongenetics professionals were statistically significantly different (P<0.005). NA indicates not applicable.

confidence and practical knowledge surrounding genetic testing in cardiology, (2) most providers do not want to be the sole provider of genetic testing for inherited cardiac conditions, and (3) education and the establishment of professional genetic guidelines were identified as possible approaches to increasing the use of genetic testing in the clinical management of patients with inherited cardiac conditions and at-risk relatives. Our study sample included providers who self-identified as genetics professionals and those who did not. This allowed the comparison of current practices, confidence, and practical knowledge between these 2 groups. Consistency of the data was a strength of our study. Results showed participants are self-aware of the deficits in their knowledge of genetic testing for inherited cardiac conditions. Practical knowledge questions on which participants scored poorly were also the skills about which they had the least confidence and were the most desired topics for an educational program.

Our results align with previous studies showing health care providers regard their knowledge and practical cardiovascular genetic skills as insufficient.[18–20] In our study, most nongenetics providers reported high confidence in identifying clinical situations in which genetic testing is warranted and the best person in the family to initiate testing. Practical knowledge was consistent with providers' confidence as most providers correctly answered the questions covering these 2 topics. Nongenetic providers in this study were less confident about ordering a specific genetic test, interpreting the results, or making treatment recommendations based on results, and thus referred to genetics based on these limitations. Our study did identify some participants who do not routinely refer their patients, and their lack of confidence and practical knowledge about ordering, interpreting, and using genetic testing to guide medical management of cardiology patients is potentially further limiting the use of genetic testing among nongenetic providers.

Participants reported that they do not want to be the sole provider of genetic testing for their patients and preferred to make referrals. Most nongenetic providers in this study reported access to a genetics provider with whom they can consult and to whom they can refer their patients. Notably, most nongenetic providers referred and had genetic testing performed for their patients once a month or less. Despite most reporting

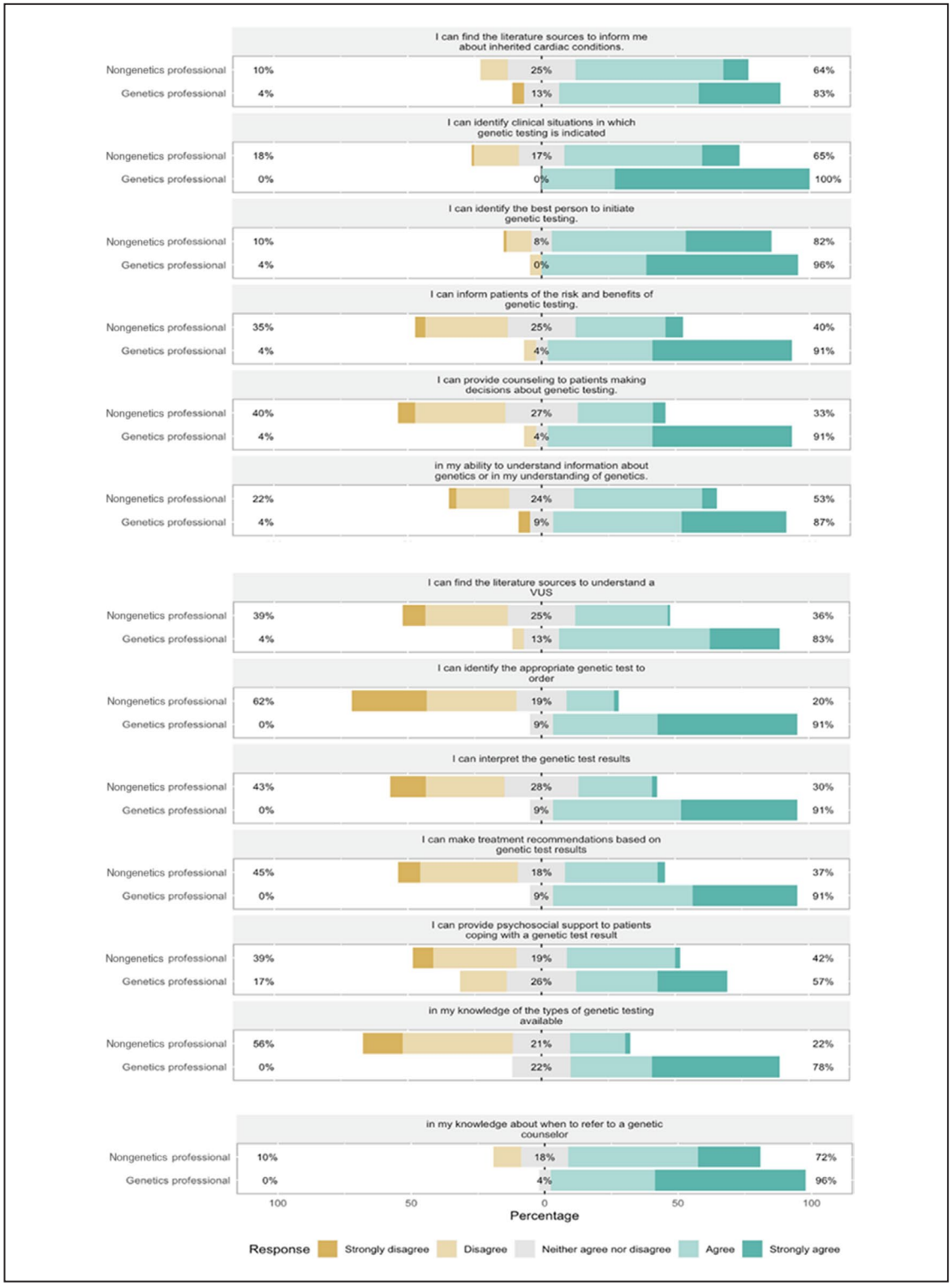

Figure 3. Health care providers' confidence in their knowledge about genetic testing in cardiology.
Participants' responses to 13 "I feel confident in …" statements. Respondents were asked to assess how confident they felt with each task on a Likert scale, from "strongly disagree" to "strongly agree." Percentages along the left axis represent the percentages of participants who are not confident in the task (participants who "strongly disagreed" or "disagreed"). Percentages centered in the gray boxes represent percentages of participants who neither agree nor disagree to have confidence in the task. Percentages along the right axis represent the percentages of participants who feel confident with the task (participants who "strongly agreed" or "agreed"). With the exception of confidence to "identify the best person to initiate genetic testing," confidence scores for all questions differed statistically significantly (P<0.005) between genetics and nongenetics professionals. VUS indicates variant of uncertain significance.

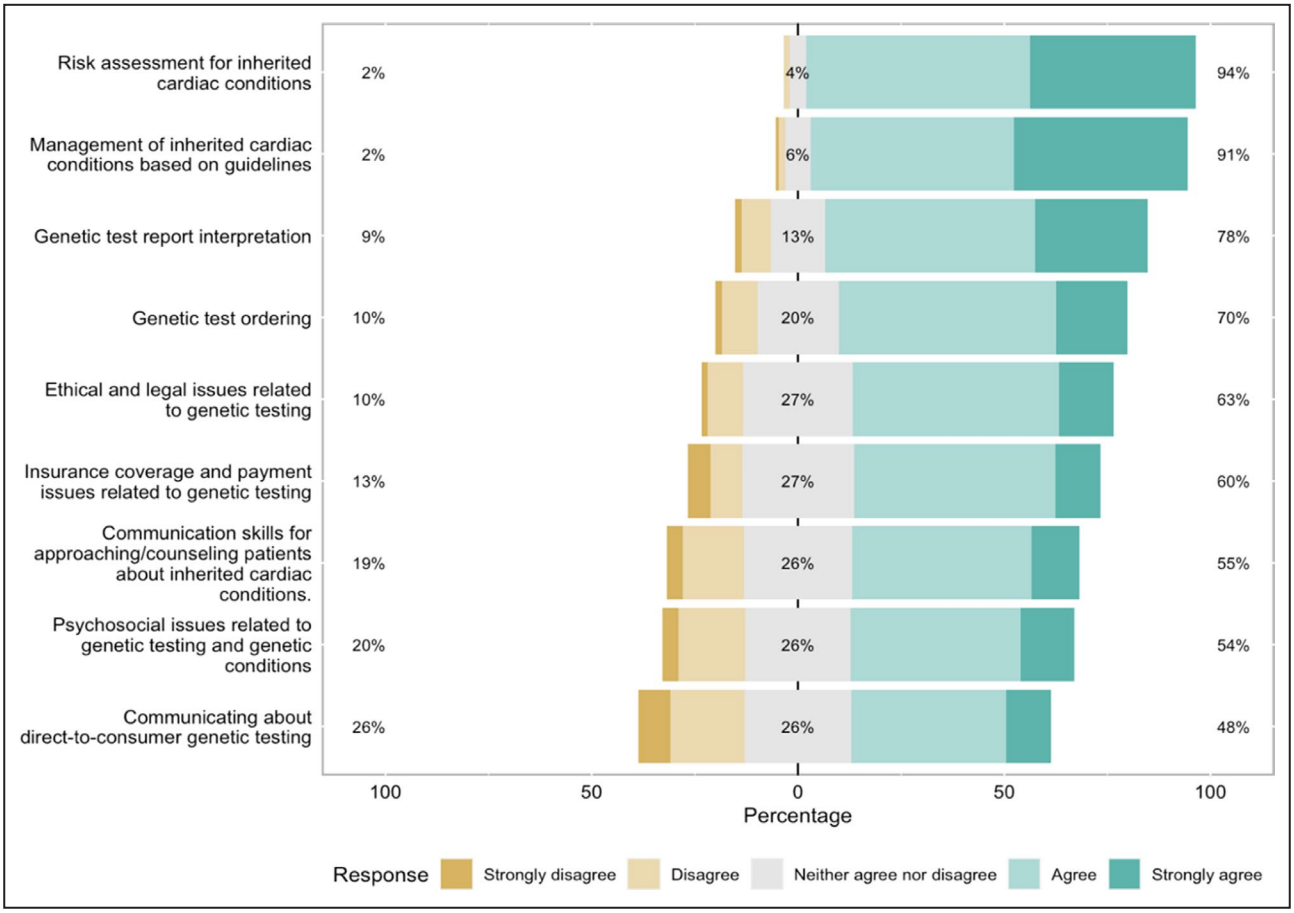

Figure 4. Desired topics for an educational program about cardiovascular genetic testing.
Respondents were asked to indicate whether they would like to see the following topics covered in a continuing medical education program about genetic testing relevant to cardiology using a Likert scale, ranging from strongly disagree to strongly agree. Percentages along the left axis represent the percentages of participants who would not like to have the topic included in the educational program (participants who "strongly disagreed" or "disagreed"). Percentages centered in the gray boxes represent percentages of participants who neither agree nor disagree to have the topic included in the educational program. Percentages along the right axis represent the percentages of participants who would like to have the topic included in the educational program (participants who "strongly agreed" or "agreed").

access to a genetics provider with whom they can consult and to whom they can refer their patients, most nongenetic providers referred and had genetic testing performed for their patients once a month or less.

A clear need and desire exist to address the knowledge deficit surrounding genetic testing in cardiology among nongenetics professionals. Although a minority of participants reported barriers to implementing genetic testing into their practice, most participants who reported barriers also reported lack of education as a barrier. Moreover, when asked about desired topics for an educational program on cardiovascular genetics, the most desired topics aligned with confidence and knowledge deficits: management of inherited cardiac conditions based on guidelines, risk assessment of inherited cardiac conditions, and topics surrounding genetic testing, including ordering and interpreting genetic test results. Online medical educational modules have proved effective in creating positive change in health care providers' knowledge and practice.[23,31] Educating nongenetics providers on genetics has been shown to improve referral decisions and confidence in genetics and consultation skills in other areas of medicine, like oncology.[16,32]

Educational programs are a useful approach to begin addressing lack of confidence and knowledge but are not likely sufficient alone. In a previous study, Wilkes and colleagues (2017) assessed the efficacy of a web-based general genetics curriculum among primary care providers and showed that even though the intervention demonstrated a significant increase in factual learning and retention, there were few differences in clinical behavior.[33] The authors of the study suggested that clinically available resources (eg, evidence-based information) may promote active engagement. Similarly, many cardiologists stressed the need for published genetic guidelines in cardiology.[18] This aligns with our findings. Most participants reported evidence-based

professional society guidelines as a motivator to incorporating genetic testing into their practice. Although contradictions exist about the impact of professional guidelines on providers' practice,[34] this study suggests both education and professional guidelines may motivate incorporation of genetics and improvement in clinical care and management of patients with inherited cardiac conditions and those at risk for SCD.

This study was limited by the lack of demographic diversity of its participants. The vast majority of respondents were from urban regions and worked at university medical centers with access to genetics services. Therefore, this sample is not representative of cardiovascular cardiology practitioners in the United States. Health care providers in different geographic regions and work settings who have varied access to genetics services might have different practices, confidence, and knowledge about genetic testing in cardiology. Moreover, most respondents have been practicing for >10 years. It is possible that with a younger cohort, the confidence and knowledge surrounding genetics might be different as medical education continually evolves and there has been an increase in the genetics content incorporated in newer curricula.

Practitioners' current practices surrounding genetic testing in the cardiology field highlight the importance of access to genetic services. Additional research is required to further explore practitioners' practices and access to genetics services in different settings like, for example, in rural geographical locations.

CONCLUSIONS

As new cardiogenetics knowledge is integrated into health care, it will be essential to ensure that practitioners acquire and maintain the necessary competencies to guide patients with inherited cardiac conditions along the pathways of screening, diagnostics, monitoring, and management. Our study emphasizes the importance of access to genetics services in the cardiology field and the need for addressing the identified deficit in confidence and knowledge surrounding cardiogenetics and genetic testing. The results of this study will be used to guide the development of an online educational program about cardiovascular genetics and genetic testing, with the ultimate goal of reducing morbidity and mortality from these conditions. Ideally, subsequent research in this area will include more practitioners from underserved areas or organizations and hospitals/medical centers that do not have genetic counselors on staff.

ARTICLE INFORMATION

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Disclosures

EMM has been a consultant for Avidity, Amgen, AstraZeneca, Cytokinetics, Invitae, Janssen, Pfizer, PepGen, Tenaya Therapeutics, Stealth BioTherapeutics; she is also the founder of Ikaika Therapeutics. These activities are unrelated to the content of this manuscript.

Supplemental Material

Data S1

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SUPPLEMENTAL MATERIAL

Data S1.

SURVEY

Inclusion criteria:

A) Are you licensed MD, DO, PA, RN or APRN in the United States?

0. No 1. Yes

B) If so, do you provide direct patient care in the United States?

0. No 1. Yes

PART I: Current practices

1. How often did you discuss genetic testing for inherited cardiac conditions with patients in 2019?
    - Never
    - Once in the year
    - Once a month
    - Once a week
    - More than once a week

2. How often did you refer said patients to genetics?
    - Never
    - Once in the year
    - Once a month
    - Once a week
    - More than once a week

3. How often are genetic tests performed for your patients?
    - Never
    - Once in the year
    - Once a month
    - Once a week
    - More than once a week

4. Do you consider yourself to be a genetics professional (medical geneticist, or a physician with genetic expertise) in the field of Cardiology?
    - Yes
    - No

5. I have access to a genetics professional (genetic counselor, medical geneticist, or a physician with genetic expertise) to whom I can **refer** patients specifically for issues relating to inherited cardiac conditions

- Strongly disagree
- Disagree
- Neither agree nor agree
- Agree
- Strongly agree

6. I have access to a genetics professional (genetic counselor, medical geneticist, or a physician with genetics expertise) with whom I can **consult** about clinical care specifically for issues relating to inherited cardiac conditions
    - Strongly disagree
    - Disagree
    - Neither agree nor agree
    - Agree
    - Strongly agree
    - I consider myself a genetics professional

7. Please indicate what your desired course of action would be for the following situations

	I would like to refer them to a genetics professional	I would like to address it myself	I would do something else
Discussing genetic testing options with a patient			
Discussing the implications of positive results with a patient			
Discussing the implications of uncertain results with a patient			
Discussing implications to family members (referring family members).			

8. Are you experiencing any barriers/frustrations in implementing genetic testing into your practice?
    - Yes
    - No

    if NO, skip logic to #11

9. Below are some of the common barriers to implementing genetic testing into practice. Please indicate whether you think each of the following is a barrier to YOU integrating genetic testing into your practice.

	Yes, this is a barrier	No, this is not a barrier
Genetic testing takes additional time		
Genetic testing is too costly or not reimbursable.		
I require more education		
Genetic testing could increase patient anxiety about their risks for inherited cardiac conditions		
Genetic testing could increase insurance discrimination		

10. Is there a barrier we haven't listed here? if so, please write in:_____

11. Please indicate whether you think each of the following would motivate you to incorporate more genetic testing into your practice.

	Yes, this would motivate me	No, this does not motivate me
Evidence-based professional society guidelines		
Cost/benefit data		
Patients requesting testing		
Evidence from the medical literature that your patient population is at increased risk for carrying pathogenic variants in genes that increase their risk for heart disease/ Sudden cardiac death (SCD)		
If the electronic health record provided an inherited cardiac condition risk assessment to flag appropriate patients		
Being involved in the care of a patient with a pathogenic variant in a gene that increases their risk for heart disease/Sudden cardiac death (SCD)		
Being personally affected by an inherited cardiac condition or having a close family member or friend with an inherited cardiac condition		
Is there anything else that would motivate you that has not been listed above? If so, please let us know here.: _____		

PART II: Confidence in genetics knowledge

12. How much do you agree with the following statements?

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree
I feel confident in my ability to understand information about genetics or confident in my understanding of genetics					
I feel confident I can find the literature sources to inform me about inherited cardiac conditions.					
I feel confident that I can identify clinical situations in which genetic testing for inherited cardiac conditions is indicated.					
I feel confident that I can identify the best person to initiate genetic testing.					
I feel confident that I can inform patients of the risk and benefits of genetic testing.					
I feel confident I can provide counseling to patients making decisions about whether or not to have genetic testing.					
I feel confident in my knowledge of the types of genetic testing available.					
I feel confident that I can identify the appropriate genetic test to order.					
I feel confident that I can interpret the genetic test results returned from a clinical lab.					
I feel confident I can find the literature sources to inform me about and understand a variant of uncertain significance (VUS).					

I feel confident that I can make treatment recommendations based on genetic test results.					
I feel confident I can provide psychosocial support to patients coping with a genetic test result.					
I feel confident in my knowledge about when to refer to a genetic counselor.					

PART III: Cardiogenetic Knowledge

13. In patients with arrhythmogenic right ventricular cardiomyopathy and a history of sudden cardiac arrest (SCA), an implantable cardioverter-defibrillator (ICD) is recommended if meaningful survival greater than 1 year is expected.
    - **True**
    - False

14. A cardiomyopathy panel is the genetic test recommended for first degree relatives of patients with hypertrophic cardiomyopathy (HCM) due to a known causative mutation.
    - True
    - **False**

15. Evaluation for genetic arrhythmia syndromes is recommended in young patients (<40 years of age) with unexplained SCA who do not have ischemic or other structural heart disease.
    - **True**
    - False

16. Genetic testing for inherited cardiac conditions is recommended to be initiated in the most clearly affected family member.
    - **True**
    - False

17. A patient with non-ischemic cardiomyopathy and a heterozygous Lamin A/C mutation is being evaluated for a primary prevention implantable cardioverter-defibrillator (ICD). According to the 2017 AHA/ACC/HRS Guidelines for management of patients with ventricular arrhythmias and prevention of sudden cardiac death, which of the following

should not be considered during evaluation for a primary prevention ICD in patients with a Lamin A/C variant?

- Male sex
- Whether the Lamin A/C variant is a missense or truncation mutation.
- **Whether the patient is over 40 years of age**
- Whether the patient has a left ventricular ejection fraction less than 45%

Part IV: CME

** We recognize that how clinicians engage in education has been impacted by the COVID-19 pandemic. For the following questions, please consider your education preferences assuming all of these options are safely available to you.

18. What would be your preferred delivery method for online learning? Please rank your top 4 choices in increasing order (meaning 4 is your most preferred delivery method).

__ Article
__ A comprehensive website with clinical resources and to support clinical care.
__ Educational modules
__Discussion Board (online group discussions)
__ PowerPoint slides
__ Podcast
__ Webinar
__recorded lecture

Is there a CME delivery method that was not listed above that you like? if so, please let us know here.:_____

19. What is your preferred format for content for an online CME?
    - I prefer active learning content such as case-based learning, patient simulations and online group discussions.
    - I prefer passive learning content such as recorded lectures and written materials.

20. When participating in online CME, what device do you mostly use?
    - Mobile device (phone or tablet)
    - Computer/laptop
    - Both

21. Please indicate whether you would like to see the following topics covered in a CME program about genetic testing relevant to cardiology

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree
Risk assessment for inherited cardiac conditions					
Genetic test ordering					
Genetic test report interpretation					
Management of inherited cardiac conditions based on guidelines					
Communication skills for approaching/counseling patients about inherited cardiac conditions					
Psychosocial issues related to genetic testing and genetic conditions					
Ethical and legal issues related to genetic testing					
Insurance coverage and payment issues related to genetic testing					
Communicating about direct-to-consumer genetic testing					

22. Would you be interested in participating in online group discussions (e.g. listserv, webinars, etc) about genetics and genomics relevant to cardiology?
    - o Yes
    - o No
    - o Unsure

IF YES or Unsure:
Would you like to provide your email where we can contact you about the online group?
* Note: This response is not linked to you other answers.
    - o Yes:_____
    - o No

PART V: Demographics

23. What best describes your training or educational background (**please select all that apply**):

- Resident
    - Please write the specialty of your residency: _____
- Fellow
    - Please write the specialty of your fellowship: _____
- Internist
- General Pediatrician
- Pediatric Cardiologist
- Cardiologist: Electrophysiology
- Cardiologist: Cardiomyopathy and/or heart transplant
- Cardiologist: Invasive
- Cardiologist: Non-invasive
- PA
- APN
- Registered Nurse
- Other practitioner, not listed above:_____

24. How long have you been practicing medicine?

- Still in residency
- < 5 years
- 5-10 years
- 10-15 years
- >15 years

25. Which of the following best describes your primary work setting?

- Private Group Practice
- Private Solo Practice
- University Medical Center
- Private Hospital/Medical Facility
- Public Hospital/ Medical Facility
- Diagnostic Laboratory/Testing Laboratory
- Other:_____

26. In which geographic region is your primary work setting?

- Urban
- Suburbs
- Rural

27. What is your current gender identity?

- Male
- Female
- Trans male/Trans man
- Trans female/Trans woman
- Genderqueer/Gender non-conforming
- Agender
- Prefer not to disclose gender identity
- Prefer to self-describe gender identity:_____

28. Are you Hispanic/Latino/a?

- Yes
- No
- Prefer not to disclose

29. With which racial and ethnic group(s) do you identify? (please select all that apply)?

- American Indian/Alaskan Native
- Asian (e.g., East/South/Southeast)
- Middle Eastern/North African
- Black/African American
- Native Hawaiian/Pacific Islander
- White
- Mixed race
    - Which ones: _____
- Other: _____