

Residents' understanding of adult congenital heart disease

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Abstract

Objective: Medical residents are exposed to increasing numbers of adults with congenital heart disease (ACHD). While inadequate ACHD knowledge may lead to inappropriate practice, this educational deficit has not been investigated. Our aim was to analyze residents' attitudes, perceived ability, and knowledge of ACHD medicine.

Design, Methods, Outcome Measures: A single center, multiprogram cross-sectional study was conducted in 2015 using an electronic survey to assess 472 medical residents' perceived knowledge and self-assessed skills related to ACHD medicine. Demographic data obtained included age, gender, level of training and program type.

Results: The survey was completed by 25% of surveyed residents ($N = 116$, median age 29.5 years, 39% male). Responses were received from Family Physician (FP; 8.5%), Internal Medicine (43%), Pediatrics (34%), Internal Medicine-Pediatrics (IM-P; 7%), and Transitional residents (4%). There was no difference between ACHD knowledge and year of residency ($P = \text{NS}$). IM-P residents were more confident in their knowledge and assessment of ACHD patients ($P < .05$). Those with prior cardiology elective during residency (59%) demonstrated a significant correlation with ACHD knowledge ($P < .05$) and confidence in ability to assess ACHD patients ($P < .05$). Overall, knowledge and confidence in ACHD assessment trended towards a positive correlation ($P = .061$, gamma statistic = 0.8). Residents' learning preferences included ACHD lectures (81.6%) and web sites (60.2%).

Conclusion: Most residents in this study lacked ACHD knowledge or comfort level required to care for adults with complex defects. Still, residents remain interested in teaching venues to improve examination skills. Residency programs should include routine cardiology electives to prepare residents to care for this complex group of patients.

KEYWORDS

adult, congenital heart disease, graduate medical education, knowledge, medical education

1 | INTRODUCTION

Mortality rates in adults with congenital heart disease (ACHD) have declined over the last several decades as a result of advances in both the long-term care and improved management of this population.¹ By the year 2000, the number of ACHD patients in the United States was rapidly approaching 1.3 million.^{2,3} As a result of observed demographic changes over the last two decades, the overall CHD population has aged, with a median age of 40 years for the entire ACHD population in 2000 and 29 years of age in the subset of adults with severe CHD.⁴

Consequently, this growing ACHD population is at variably increased risk for a range of late-onset complications that include heart failure, arrhythmia, and sudden cardiac death.^{5,6} Until now, hospitalization patterns for ACHD patients in the United States had not been investigated. Consequently, an analysis of the Nationwide Inpatient Sample (NIS), the largest publicly available all-payer inpatient care database in the United States, from 1998 to 2005 demonstrated a 101.9% increase in ACHD hospitalizations during this time period.⁷ The average patient age was 53.8 years with a significant proportion of patients with two or more medical comorbidities. As a result of increasing number of ACHD admissions, health care

providers in all specialties will encounter these complex patients with increasing frequency.

There is now a growing need to educate a broader professional audience on the principles and challenges regarding care of the ACHD patient.⁸ This broader audience should not only include general cardiologists, family physicians, and health care professionals but also medical residents. The question that remains is whether or not medical residents are ready to tackle the complex ACHD patient during residency training. The current literature does not include any studies investigating the knowledge or comfort level of medical residents in the participation of complex ACHD care. Through an electronic survey, we performed a multiprogram assessment of residents' attitudes, perceived ability, and knowledge of ACHD medicine.

2 | METHODS

2.1 | Study design, setting, and participants

We conducted a cross-sectional survey of resident physicians in Family Medicine (FM), Internal Medicine (IM), Internal Medicine-Pediatrics (IM-P), Pediatrics and Transitional-year residents at three sites: University of Pittsburgh Medical Center (UPMC), UPMC Shadyside and Children's Hospital of Pittsburgh of UPMC. In 2015, 472 trainees were invited to complete an anonymous survey via an on-line survey tool (surveymonkey.com) with encrypted responses. Surveys were reviewed and approved by the institutional review board (IRB) and all survey responses were anonymous.

The survey included four sets of questions: (1) eight demographic questions that included age, gender, advanced degrees, current training level, residency program type, cardiology interest, past training in cardiology, and current journal reading practices; (2) five ACHD awareness questions that included three site-specific questions; (3) eight questions that focus on resident perception and self-assessed skills about the evaluation and management of acute heart failure or arrhythmias in the ACHD patient; and (4) one final question to address preferred educational formats (Appendix). Questions regarding ACHD awareness were multiple choice. Questions that focused on attitudes, perception, and self-assessment skills were assessed using a 5-point Likert scale in which 1 translated to no confidence and 5 indicated complete confidence.

2.2 | Statistical analysis

On completion, survey results from each site were combined and tabulated. The primary group comparisons were made based on training program (FM, IM, IM-P, pediatrics, and transitional). Residents' ACHD awareness was scored by determining the percentage of correct questions. Strength of association of categorical variables was measured by crosstabulation with the gamma statistic. Continuous variables were assessed by the Mann-Whitney *U* test. Statistical analyses were performed using SPSS v21 (IBM Corp, Armonk, NY). Results were considered statistically significant when $P < .05$.

TABLE 1 Characteristics of survey respondents ($n = 116$)

Demographic variable	Statistic (% or Median with IQR)
Gender (female)	61%
Age	30 (28-31)
Residency program type	
Internal medicine	43%
Pediatrics	34%
Internal medicine-pediatrics	7%
Family care physician	9%
Preliminary/transitional year	4%
Other	3%
Other advanced degrees	
Doctor of Philosophy (PhD)	3%
Master of Public Health (MPH)/science (MPS)	4%
Years since medical school graduation	
< 1	26%
1-3	63%
4-10	11%
Current level of training	
Experienced intern ^a	33%
I	2%
II	37%
III	26%
IV	2%
Previous training in cardiology	
Cardiology elective	67%
Medical school	30%
Residency	59%
Regularly reads medical journals	38%

^aTrainees in month 10–12 in their intern year.

3 | RESULTS

The survey was completed by 116 residents (25% response rate), which is consistent with e-mail based surveys to college-level students.⁹ The median age of respondents was 29.5 years and 39% were male. Demographic characteristics of survey respondents are shown in Table 1. Over half of trainee respondents (63%) were 1–3 years post medical school training. One-third (33%) of residents completing the survey were experienced interns. The remaining (67%) consisted of second–fourth year residents. Survey responses were received from FM (9%), IM (43%), Pediatrics (34%) IM-Pediatrics (IM-P; 7%), and transitional-year residents (4%). Of all respondents, 7% had an advanced degree beyond MD or DO. Among residency training programs, respondents were evenly distributed based on gender.

There was no difference between ACHD awareness and year of residency ($P = 0.4$). Only $17\% \pm 7\%$ (95% CI) of trainee respondents accurately estimated the number of ACHD patients in the United States today, while just less than half ($47.5\% \pm 9\%$) accurately identified the correct ratio of adults:children with congenital heart disease. Additionally, 76% of trainee respondents correctly identified an ACHD

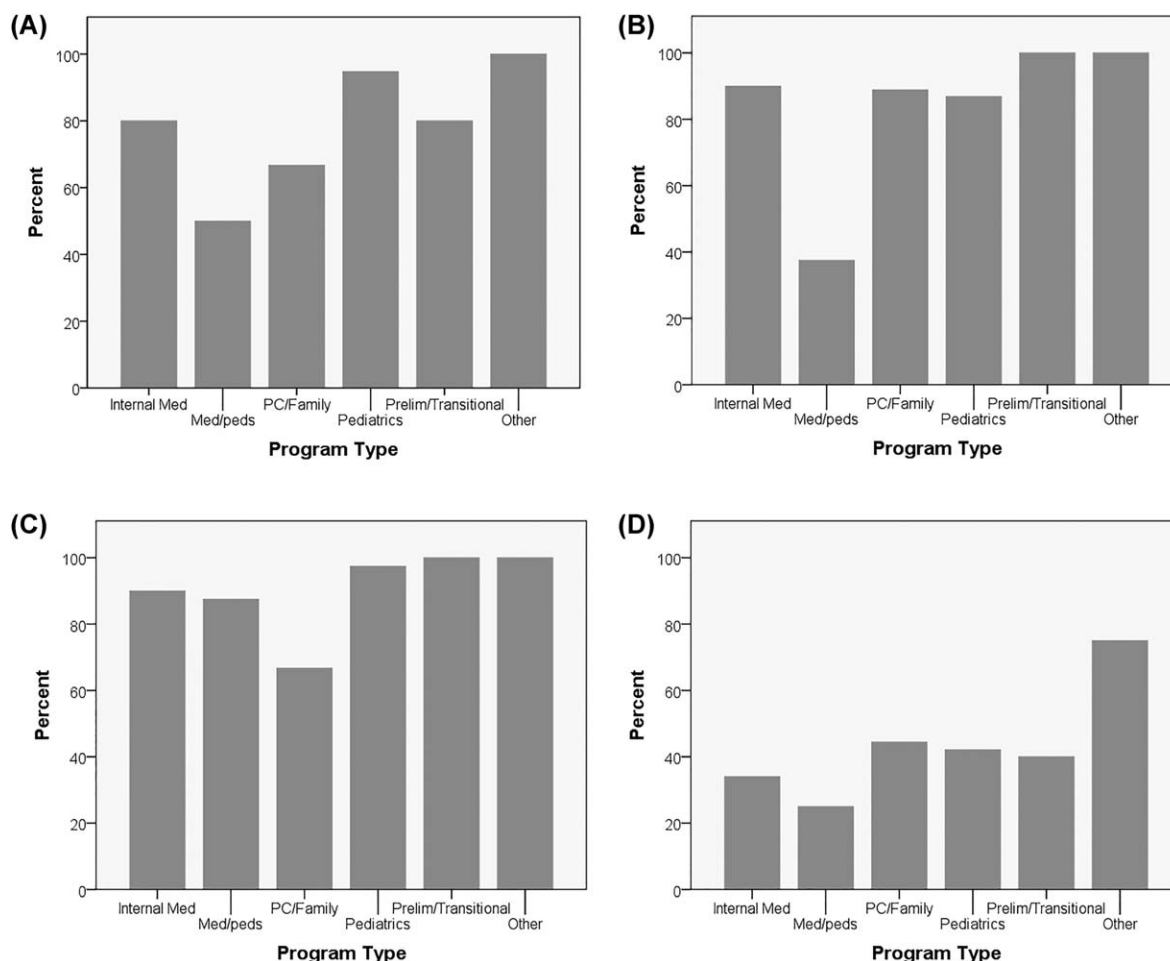


FIGURE 1 Percentage of residents self-reporting the need for close supervision/instruction in areas of ACHD care by residency program type. (A) Heart failure. (B) Assessment and patient plan. (C) Arrhythmia. (D) Collaborate with multidisciplinary team

program at UPMC. Still, 20% revealed that they were unaware of the ACHD program. Less than half (44%) knew how to contact the ACHD program. Notably, 93% of survey respondents agreed that academic centers should have access to an ACHD program to collaborate in the management of ACHD patients.

Nearly three-quarters of trainee respondents had provided care to an ACHD patient prior to completing the survey. Internal Medicine-Pediatric residents were more confident in their perceived knowledge and self-assessment of ACHD patients ($P < .05$) (Figure 1). The majority of residents reported either further basic instruction or management with close supervision was required to manage common complications (e.g., heart failure, arrhythmias) as well as their ability to perform a complete physical examination in the ACHD patient (Table 2).

Residents with advanced degrees were 8% more likely to require minimal supervision in managing ACHD arrhythmias ($P = .02$). However, they were equally likely to require additional supervision or more instruction in all other categories (ACHD HF, Patient Assessment, ACHD team collaboration). At least 67% of respondents had taken a cardiology elective during medical school (30%) or residency (59%). Of those with prior cardiology elective during residency, there was a significant correlation with ACHD awareness ($P < .05$) and confidence in

ability to assess ACHD patients ($P < .05$). Overall, awareness and confidence in ACHD assessment trended towards a positive correlation ($P = .061$, gamma statistic = 0.8).

Routine review of medical journals did not correlate with either ACHD knowledge or confidence with patient care ($P = \text{NS}$). Still, less than half of all residents (37%) reported reading peer-reviewed medical journals. Most residents thought it would be "useful" or "very useful" to include ACHD lectures (81.6%), web sites (60.2%), or grand rounds (55.6%) during residency training (Figure 2).

4 | DISCUSSION

In this multiprogram survey of medicine residents' confidence in, attitudes toward and knowledge of ACHD care, 53% of residents reported that ACHD knowledge is important to provide accurate care to these complex patients. Yet, 86% residents acknowledged requiring either further basic instruction or close supervision in patient assessment to create a care plan to address ACHD patient needs. This lack of confidence was further validated by low ACHD awareness scores. Overall, IM-P residents surpassed residents from all other training programs.

TABLE 2 Residents' perceived competence in clinical assessment and management of common complications encountered in the adult with CHD^a

Clinical activity	Percent (%) requiring close supervision or further instruction
Assess and manage CHF ^b	82.5
Assess and manage arrhythmias	91.2
Patient assessment and care plan	86
Collaboration with ACHD ^c Team	38.6

^aCHD, congenital heart disease.

^bCHF, congestive heart failure.

^cACHD, adult congenital heart disease.

Among these residents, confidence in their perceived knowledge and self-assessment of ACHD patients may reflect exposure to faculty with cardiology training or teaching experience. Previous training in cardiology during residency was associated with improved ACHD awareness and confidence in ability to assess ACHD patients. We speculate that the presence of an ACHD program at an academic center might offer residents opportunities to participate in ACHD management. This highlights the importance of residency training that includes cardiology elec-

tives that may in turn provide greater exposure to the basic principles of ACHD patient management. Still, poor knowledge in the evaluation and management of ACHD patients likely represents insufficient training. Thus, diagnostic uncertainty may impair residents' ability to make appropriate decisions regarding patient care. Guidelines for the management of the ACHD patient are now well established.¹⁰ However, these patients represent a heterogeneous group with a variety of different primary congenital diagnoses and medical comorbidities. These results suggest the need for more effective cardiology training, including the management of ACHD patients, during residency.

Programs implementing cardiology curricula can assess several teaching resources. Teaching formats that include teaching background information, analyzing cases, and questions, and those formats that verify understanding with medical residents, demonstrated an improvement in initial knowledge achievement, as well as a trend toward long-term knowledge retention.¹¹ Further, the effectiveness of randomized tracks of prerecorded cardiac sounds as a teaching tool for cardiac auscultation indicated that residents improved at detecting any cardiac murmur ($P = .007$).¹² In this study, residents increased their ability to detect heart disease when present. Teaching that specifically targets the cardiovascular examination may improve residents' ability to examine the ACHD patient, detect heart disease when present and ensure

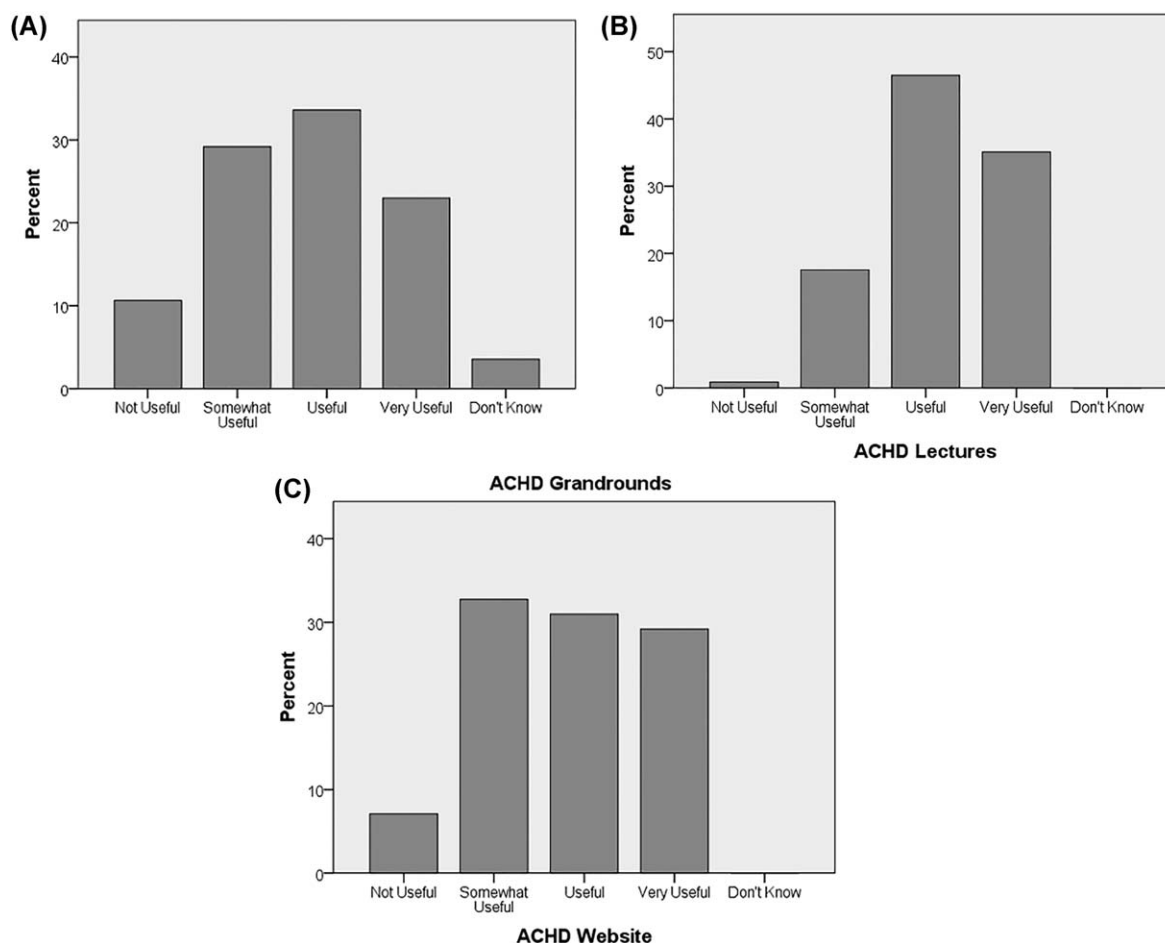


FIGURE 2 Trainee responses for structured adult congenital heart disease education by opinion on the importance of ACHD knowledge in providing appropriate patient care. (A) ACHD grand rounds ($P < 0.1$) (B) ACHD lectures ($P < .05$) (C) ACHD Web site ($P < .05$)

appropriate referrals are made to experts in the management of the complex ACHD patient.

Limitations of this study include the conciseness of the survey limiting our ability to assess not only understanding of additional ACHD concepts but also the lack of comparison to other subspecialties of medicine. We were also limited in a comprehensive assessment of the ACHD patient based on residents who responded to the survey. Residents, who did not respond, either by choice or by chance, may have scored differently. Lastly, the residents in our survey were limited to one program (UPMC).

Despite these limitations, this was the first multiprogram study to capture information regarding ACHD knowledge and evaluation from a wide range of medicine residents from different types of residency programs. Survey respondents agreed that academic centers should have access to a regional ACHD center for consultation. Still, this survey identified a deficiency of ACHD knowledge. To improve medical knowledge of this subspecialty of cardiology most residents' learning preferences included ACHD lectures (81.6%) or access to web sites (60.2%) where ACHD information could be obtained. While residents desire active learning, prior studies performed to identify challenges in resident conferences have shown that faculty describe difficulty with facilitating active learning, even amongst seasoned educators.¹³ Our results provide practical guidance to aid in residency education and an opportunity to provide effective learning opportunities. Rather than ACHD lectures that focus solely on information dissemination, lecture format should now be revised to information application and clinical reasoning specific to the ACHD patient.^{14,15}

5 | CONCLUSIONS

Even though the number of ACHD patients continues to increase, basic concepts that include physical examination and development of care plans are not well understood by resident physicians. Inability to perform these skills demonstrates lack of competence in meeting part of the Accreditation Council for Graduate Medical Education's practice-based learning and improvement requirements.¹⁶ If physicians are unable to provide care that is effective for the treatment of ACHD patients, inadequate evaluation may lead to inappropriate therapies and poor patient outcomes. The educational program and faculty should reevaluate how this information is taught to best prepare trainees for lifelong learning. Future research is needed in this area to determine effective educational methods and to assess its impact on house staff knowledge and self-assessment.

CONFLICT OF INTEREST

None.

AUTHOR CONTRIBUTIONS

All authors meet conditions 1, 2, and 3 for publication. All authors gave final approval to the submitted manuscript.

REFERENCES

- [1] Marelli AJ, Gurm M. From numbers to guidelines. *Prog Cardiovasc Dis*. 2011;53:239–246.
- [2] Hoffman JI, Kaplan S. The incidence of congenital heart disease. *J Am Coll Cardiol*. 2002;39:1890–1900.
- [3] Hoffman JI, Kaplan S, Liberthson RR. Prevalence of congenital heart disease. *Am Heart J*. 2004;147:425–439.
- [4] Marelli AJ, Mackie AS, Ionescu-Ittu R, Rahme E, Pilote L. Congenital heart disease in the general population: changing prevalence and age distribution. *Circulation* 2007;115:163–172.
- [5] Somerville J. Management of adults with congenital heart disease: an increasing problem. *Annu Rev Med*. 1997;48:283–293.
- [6] Perloff JK. Adults with surgically treated congenital heart disease. Sequelae and residua. *JAMA*. 1983;250:2033–2036.
- [7] Opatowsky OR, Siddiqi OK, Webb GD. Trends in hospitalizations for adults with congenital heart disease in the U.S. *J Am Coll Cardiol*. 2009;54:460–467.
- [8] Gatzoulis MA. Adult congenital heart disease: education, education, education. *Nat Clin Pract Cardiovasc Med*. 2006;3:2–3.
- [9] Kaplowitz MD, Hadlock TD, Levine R. A comparison of web and mail survey response rates. *Public Opin Q*. 2004;68:94–101.
- [10] Warnes CA, Williams RG, Bashore TM, et al. ACC/AHA 2008 guidelines for the management of adults with congenital heart disease: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Develop Guidelines on the Management of Adults With Congenital Heart Disease). Developed in Collaboration With the American Society of Echocardiography, Heart Rhythm Society, International Society for Adult Congenital Heart Disease, Society for Cardiovascular Angiography and Interventions, and Society of Thoracic Surgeons. *J Am Coll Cardiol*. 2008;52:e143–e263.
- [11] Sawatsky AP, Berlacher K, Granieri R. Using an ACTIVE teaching format versus a standard lecture format for increasing resident interaction and knowledge achievement during noon conference: a prospective, controlled study. *BMC Med Educ*. 2014;14:129–134.
- [12] Mattioli LF, Belmont JM, Davis AM. Effectiveness of teaching cardiac auscultation to residents during an elective pediatric cardiology rotation. *Pediatr Cardiol*. 2008;29:1095–1100.
- [13] Sawatsky AP, Zicmund SL, Berlacher K, Lesky D, Granieri R. Understanding the challenges to facilitate active learning in the resident conferences: a qualitative study of internal medicine faculty and resident perspectives. *Med Educ Online*. 2015;20:27289.
- [14] Teunissen PW, Scheele F, Scherpier AJ, et al. How residents learn: qualitative evidence for the pivotal role of clinical activities. *Med Educ*. 2007;41:763–770.
- [15] Murad MH, Coto-Yglesias F, Varkey P, Prokop LJ, Murad AL. The effectiveness of self-directed learning in health professions education: a systematic review. *Med Educ*. 2010;44:1057–1068.
- [16] Accreditation Council for Graduate Medical Education (ACGME). Outcome project: enhancing residency education through outcomes assessment. <http://www.acgme.org/ProgramRequirements>. ACGME approved focused revision. Accessed September 28, 2014; effective: July 1, 2015.

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APPENDIX: ADULT CONGENITAL HEART DISEASE SELF-ASSESSMENT QUESTIONNAIRE

Demographics & training

1. Gender
 - a. Male/Female
2. Age
3. Advanced degrees
 - a. MD, DO, MD/PhD, other (MPH, MSc)
4. Current level of training
 - a. Intern; first-fourth year resident, Chief resident
5. Residency training program type
 - a. Internal Medicine, Internal Medicine-Pediatrics, Primary Care/Family Practice, Pediatrics, Preliminary/Transitional
6. Have you ever performed an elective in cardiology?
 - a. Yes/No
 - b. If yes: medical school, residency
7. What is your level of interest in cardiology?
 - a. No interest, Slightly, Moderate, Very, Extremely interested
8. Do you regularly read medical journals?
 - a. Yes/No

ACHD awareness

1. What is the estimate of adult congenital patients in the US?
 - a. 200,000; 500,000; 800,000; 1,000,000
2. Which of the following statements is true about the congenital heart disease population.
 - a. There are more children with congenital heart disease than adults
 - b. There are more adults with congenital heart disease than children
 - c. There is an equal number of children and adults with congenital heart disease
 - d. None of the above
3. Have you provided care for an ACHD patient?

- a. Yes/No
4. Does your hospital have an ACHD program?
 - a. Yes, No, Do not know
5. Do you know how to contact the ACHD program?
 - a. Yes, No, Do not know

Attitudes & perception of ACHD patient care

1. Ability to perform a patient assessment and create a care plan to address ACHD needs.
 - a. Perform independently, Minimal supervision, With close supervision, Need further basic instruction
2. Ability to work with an interdisciplinary team.
 - a. Perform independently, Minimal supervision, With close supervision, Need further basic instruction
3. Ability to assess and manage heart failure in adults with CHD
 - a. Perform independently, Minimal supervision, With close supervision, Need further basic instruction
4. Ability to assess and manage arrhythmias in adults with CHD
 - a. Perform independently, Minimal supervision, With close supervision, Need further basic instruction
5. I would rate my knowledge of ACHD medicine.
 - a. No knowledge, Beginner, Intermediate, Advanced, Expert
6. To provide appropriate care to patients, how important is knowledge of ACHD?
 - a. Not important, Slightly, Moderately, Very, Extremely
7. How helpful would you find additional training in ACHD?
 - a. Not helpful, Slightly, Moderate, Very, and Extremely
8. Every academic center should have access to a regional ACHD center for consultation and referral.
 - a. Strongly agree, Agree, Disagree, Strongly disagree, Do not know

Educational Resources

1. What additional formats would you find helpful for the care of adults with CHD during residency?
 - a. Lectures, Grand rounds, Educational web site