# Pediatric Echocardiography

## Practice Analysis Detailed Report

Approved by the ARDMS Council on December 10, 2023

# Contents

## ACKNOWLEDGEMENTS

Thank you to the subject matter expert volunteers who spent many hours developing the task inventory, evaluating the survey and responses, and reviewing the final content outline. Also, thank you to the over 500 Registered Diagnostic Medical Sonographers (RDMSs) certified in Pediatric Echocardiography around the world who took the time to participate in the practice analysis survey. This study was completed through the efforts of many individuals at Inteleos who worked together to construct the survey, administer the survey, and analyze the data.

# EXECUTIVE SUMMARY

The American Registry for Diagnostic Medical Sonography (ARDMS), part of the Inteleos family of certifications, is the globally recognized standard of excellence in sonography. The ARDMS is responsible for the preparation of valid and reliable certification examinations in the field of sonography. Conducting practice analyses at the national and international levels allows the ARDMS to evaluate the current practice expectations and performance requirements within the field. The Pediatric Echocardiography (PE) practice analysis collected information on the requisite PE knowledge, skills, and abilities essential to sonography professionals. The practice analysis was conducted in several stages:

1. *Expert Interviews and Focus Groups*
2. *Review and Revise Existing Content Outline*
3. *Review of Revised Content Outline*
4. *Field Survey and Analysis*
5. *Final Task and Domain Weighting*
6. *Knowledge, Skills, and Abilities (KSA) Development*

The result of these activities led to the PE Practice Analysis Panel recommending a new Content Outline and list of KSAs (see Appendix H). This report details the methodology, data collection, analysis, and the recommended updated test content outline for the PE examination based on the results of the practice analysis.

# BACKGROUND OF STUDY

The ARDMS recognizes that diagnostic medical sonography is a valuable tool in the healthcare industry. There are several healthcare professions that utilize sonography in practice to increase the efficacy of their patient care. Successful mastery and demonstration of the knowledge and skills required to hold ARDMS sonographer credentials will provide sonographers with an additional source of validation. This will support the veracity of the diagnostic sonography exams that these practitioners perform. The PE examination assesses the requisite pediatric echocardiography knowledge, skills, and abilities essential to sonographer-level professionals.

# METHODOLOGY

## Selection and Profile of Subject Matter Experts

The PE Assessment Committee reviewed and proposed changes to the existing content outline. A PE Practice Analysis Expert Panel was recruited and participated in all of the other stages of the practice analysis with the exception of the survey which was sent to a larger sample as described in the *Field Survey and Analysis* section of this report. The PE Practice Analysis Expert Panel was comprised of members of the PE Assessment Committee and additional experts who were selected from a pool of current RDCSs certified in PE who indicated an interest in volunteering. Efforts were made to select a panel which represented the population of RDCSs certified in PE on several demographic features. For a list of panelists, their involvement, and this demographic breakdown see Appendix A.

## Expert Interviews and Focus Groups

Inteleos contracted with the Human Resources Research Organization (HumRRO) to kick-off the practice analyses for the three RDCS exams, including PE. In January 2023, HumRRO conducted three interviews and two focus groups to gain insights into the Registered Diagnostic Cardiac Sonographer (RDCS) specialty exams' content outlines (all meetings were

held remotely). Participants were knowledgeable end-users of the content outlines (e.g., exam committee members, staff clinical specialists, program managers). The goals of these sessions were to explore the end-users' uses, challenges, and preferences related to the current content outlines and identify features of the ideal "end-states" for the outlines. For a summary of these sessions see Appendix B. For participant lists see Appendix A.

## Review and Revise Existing Content Outline

On February 2, 2023 the HumRRO project team facilitated a meeting with the PE Assessment Committee to collect feedback about the current PE content outline. The purpose of the meeting was to (a) learn what the committee members like and dislike about the outline, (b) identify how the outline can be optimized to support exam development or administration activities and tools (e.g., item banking, form assembly), and (c) discuss the integration of a standardized structure for the outline. Prior to the meeting, HumRRO prepared a set of pre-reading materials that provided instructions on performing a critical review of the content outline. Inteleos sent the materials to the committee two weeks prior to the meeting for their review. For the summary of this meeting, see Appendix C. Feedback from the interviews, focus groups, and the review of the current content outline was used to revise the content outline.

## Review of the Revised Content Outline

On June 21, 2023, and June 26, 2023, the PE Practice Analysis Expert Panel met to review and edit the revised content outline. The meetings were remote and facilitated by Cynthia Parshall from Touchstone Consulting. The meeting agendas can be found in Appendix D. These meetings resulted in an edited version of the content outline to be used to develop a list of tasks for the field survey. This included 89 tasks organized into five domains. The tasks can be found in Appendix E.

## Field Survey and Analysis

### Field Survey Structure and Instructions to Survey Participants

The field survey was divided into two parts: demographic items and the task inventory items. A screening item was used at the beginning of the survey to ensure only those actively practicing PE sonography responded to the survey: "*Do you currently perform and/or teach Pediatric Echocardiography ultrasound examinations?*" Participants who selected "No" were thanked for their time and the survey ended.
The tasks (grouped by domains) as developed by the practice analysis panel were presented to survey participants. The participants were asked to rate each task on an importance scale. The instructions for this section were:

> *In the next section of the survey, please examine the tasks associated with being a Pediatric Echocardiography Sonographer, and consider the following question:*
>
> **How important** is this task to ***your*** practice of Pediatric Echocardiography?
>
> - *Absolutely essential*
> - *Very important*
> - *Of average importance*
> - *Of little importance*
> - *Not important at all*

The rating scale and weighting calculations are described in the *Data Analysis* section below.

### Survey Administration Procedure and Response Rate

The survey was sent to a random sample of 1,500 RDCS Sonographer registrants who were at the time certified in PE. The survey was available from August 1, 2023, to August 15, 2023. The survey was administered to participants via the web-based survey platform Qualtrics®. All responses to the survey were kept confidential. The task inventory portion of the survey was completed by 503 individuals. Responses from participants who did not complete the task inventory were not used as part of the data analysis.

## Data Analysis

### Task Inventory Analysis

Each option for the 89 task inventory items was assigned the following *importance score*:

- Absolutely essential = 5
- Very important = 4
- Of average importance = 3
- Of little importance = 2
- Not important at all = 1

The mean importance score was calculated for each task (see Appendix E). Tasks were assigned to three categories to assist in the discussion of importance scores.

- Green: Any task with an importance score of four or above. These tasks should only be removed from the outline if they are redundant or for some other extraordinary circumstance. A rationale must be provided if the task is recommended for removal.
- Yellow: Tasks with an importance score of less than four and greater than or equal to three. These tasks may be kept or removed. A rationale is required for any tasks that are removed.
- Red: Any task with an importance score lower than three. These tasks should be considered for removal. A rationale is required for any of these tasks that are kept.

Most of the tasks fell into the “green” category. Three tasks fell into the “yellow” category and there were no tasks in the “red” category.

#### *Initial Domain Weightings*

The mean importance scores for each task were summed within each domain. The sum of the mean importance score for each domain was divided by the total mean importance score to determine the initial domain weightings (Table 1).

Table 1. Initial Domain Weightings (Prior to Expert Panel Review)

| Domain | # Tasks | Importance Sum | % of Total |
|---|---|---|---|
| Normal Anatomy and Physiology | 12 | 57.72 | 14% |
| Acquired Heart Disease | 12 | 54.03 | 13% |
| Congenital Anomalies | 22 | 105.16 | 25% |
| Postoperative (surgically corrected/palliated) Anatomy | 16 | 74.19 | 18% |
| Performing the Exam | 27 | 124.31 | 30% |
| Total | 89 | 415 | 100% |

### Demographic Analysis

Responses to demographic questions were also analyzed. Appendix F contains highlights from the demographic analysis. Data from the survey responses, the total population (currently registered RDCSs), and from the 2015 PE practice analysis are included where available. Here are the key findings:

- The survey respondents are representative across the dimensions of gender identification, age, location, and primary job function.
- The analysis shows that more of the survey respondents in 2023 have been working 16 or more years than in 2015.
- In the recent survey, fewer respondents were doing more than 100 scans a month as compared to the previous survey respondents.
- Although roughly the same percentage of respondents work in hospitals, the percent working in outpatient facilities nearly doubled between 2015 and 2023.

## Final Task and Domain Weighting

The final tasks and domain weightings were determined by members of the PE Practice Analysis Expert Panel at an in-person workshop held in Seattle, Washington, September 15-16, 2023. The workshop included an orientation to the activities, a discussion of key findings from the demographic analysis, a determination of the final tasks to include on the content outline based on the survey responses, and the determination of the final content domain weightings based on the survey and discussions. The workshop also included time to develop KSAs as well as some item development work. See Appendix G for the workshop agenda.

The PE Practice Analysis panel decided to remove the 2 of the 3 “yellow” tasks. They also found some additional redundancies across the tasks so the total number of tasks was reduced from 89 to 84. One task moved domains. The panelists also made some minor edits to other tasks. The complete list of tasks with the importance ratings and the comments from the panel can be found in Appendix E.

After the edits were made the domain weightings shifted slightly (see Table 2).

Table 2. Final Domain Weightings (Panel Recommendations)

| Index | Domain | # Tasks | Importance Sum | % of Total |
|---|---|---|---|---|
| 1 | Normal Anatomy and Physiology | 12 | 57.72 | 15% |
| 2 | Acquired Heart Disease | 10 | 46.12 | 12% |
| 3 | Congenital Anomalies | 21 | 100.47 | 25% |
| 4 | Postoperative (surgically corrected/palliated) Anatomy | 16 | 74.19 | 19% |
| 5 | Performing the Exam | 25 | 115.98 | 29% |
| | Total | 84 | 394 | 100% |

## KSA Development

At the in-person workshop, the expert panel developed a list of knowledge, skills, and abilities (KSAs) that are required to accomplish the tasks laid out in the updated content outline. Following a brief training on how to write KSAs, the expert panel was divided into four small groups. Each small group developed their own list of KSAs. The results from the small groups were combined into one list which was reviewed and edited by the full group. The resulting KSAs are included at the end of Appendix H.

## FINAL CONTENT OUTLINE

The revised formatted content outline including domain weightings and KSAs was formatted and provided to the PE Practice Analysis Panel for final review and approval on October 2, 2023. Minor edits were suggested by panel members (see Appendix E, comments labeled “Panel post workshop:…”). All changes were made, resulting in the final version of the content outline found in Appendix H. This report, including the final version of the content outline recommended by the Practice Analysis Panel will be presented to the ARDMS Council for approval. Upon approval of the content outline, this report will be amended to include the approval date.

Update 1/26/2024: The ARDMS Council approved the Resolution 23403: Pediatric Echocardiography Content Outline Update on December 10, 2023.

# Appendix A: Practice Analysis Participants

Table 3. Expert Interview Participants

| *First Name* | *Last Name* | *Certifications* |
|---|---|---|
| Christina | Cardoza | RDCS (AE), RVT - Staff |
| Christine | Damar | RDMS (AB, BR, OB/GYN), RVT - Staff |
| Stephanie | Tribo | Staff |

Table 4. Focus Group (with HumRRO) Participants

| *First Name* | *Last Name* | *Certifications* |
|---|---|---|
| Sandhya | Ramlogan | MD |
| Jacqueline | Weinberg | MD |
| Mandie | Freire | RDCS (AE, PE) |
| Zhanna | Roytman | RDCS (PE, FE) |
| Candice | Vacher Sigur | RDCS (AE, PE) |
| Brittany | Byrd | RDCS (AE, FE, PE) |
| Kathleen | Hoag | RDCS (FE, PE) |

Table 5. Remote Content Outline Review Assessment Committee Members

| *First Name* | *Last Name* | *Certifications* |
|---|---|---|
| Sandhya | Ramlogan | MD |
| Jacqueline | Weinberg | MD |
| Mandie | Freire | RDCS (AE, PE) |
| Zhanna | Roytman | RDCS (PE, FE) |
| Candice | Vacher Sigur | RDCS (AE, PE) |
| Brittany | Byrd | RDCS (AE, FE, PE) |
| Kathleen | Hoag | RDCS (FE, PE) |

Table 6. Expert Panel

| *First Name* | *Last Name* | *Certifications* |
|---|---|---|
| Zhanna | Roytman | RDCS (PE, FE) |
| Kimberly | Jankovsky | RDCS (AE, PE), RDMS (AB, OB/GYN), RVT |
| Jacqueline | Alonzo | RDCS (AE, PE) |
| Ashley | Gesme-Lambert | RDCS (AE, PE) |
| Carlos | Barrios | RDCS (AE, FE, PE) |
| Michael | Smarjesse | RDCS (AE, PE) |
| Julie | Grozev | RDCS (AE, FE, PE) |
| Mohammad | Saylab | RDCS (AE, PE), RVT |

Table 7. In-person Workshop Expert Panel and Assessment Committee Members

| *First Name* | *Last Name* | *Certifications* |
|---|---|---|
| Michael | Smarjesse | RDCS (AE, PE) |
| Carlos | Barrios | RDCS (AE, FE, PE) |
| Julie | Grozev | RDCS (AE, FE, PE) |
| Kimberly | Jankovsky | RDCS (AE, PE), RDMS (AB, OB/GYN), RVT |
| Ashley | Gesme-Lambert | RDCS (AE, PE) |
| Zhanna | Roytman | RDCS (PE, FE) |
| Sandhya | Ramlogan | MD |
| Jacqueline | Weinberg | MD |
| Brittany | Byrd | RDCS (AE, FE, PE) |
| Kathleen | Hoag | RDCS (FE, PE) |

Table 8. Gender Identification of Population and Panelists

| *Gender* | *Percent in Population* | *Panelists* | *Percent of Panelists* |
|---|---|---|---|
| Female | 80 % | 9 | 80% |
| Male | 20 % | 2 | 20 % |

Table 9. U.S. Region or Country of Population and Panels

| *Region* | *Percent in Population* | *Panelists* | *Percent of Panelists* |
|---|---|---|---|
| Mid-Atlantic | 9% | 1 | 9% |
| Midwest | 26% | 4 | 37% |
| Northeast | 2% | 0 | 0% |
| Northwest | 3% | 0 | 0% |
| Southeast | 20% | 2 | 18% |
| Southwest | 8% | 1 | 9% |
| West | 19% | 2 | 18% |
| International | 9% | 1 | 9% |

# Appendix B: Expert Interviews and Focus Group Summaries

## Interview and Focus Group Summary

*Introduction:*
HumRRO conducted 3 interviews and 2 focus groups about the Registered Diagnostic Cardiac Sonographer (RDCS) specialty exams' content outlines. Participants were knowledgeable end-users of the content outlines (e.g., exam committee members, clinical specialists, program managers). The goals of these sessions were to explore the end-users' uses, challenges, and preferences related to the current content outlines and identify features of the ideal "end-states" for the outlines. Below is a summary of themes that emerged from these conversations.

*Common themes:*

1) Consensus emerged that AE is the clearest and easiest to use content outline.
2) FE stakeholders will probably be the most resistant to change.
3) SMEs like the idea of organizing the outlines like a process, with caveats. A content outline with broader domains could be used with subdomains more specific to each exam.
4) Across specialties, normal anatomy is very similar but the pathology (diseases) and how you employ the technology differs.
5) Some content overlaps across content outlines.
6) Some content areas are too broad, while others may be too narrow (at least to write multiple items that aren't enemy items).
7) There are some areas in the content outlines that have to do with ability, but the test is very much about knowledge. Tasks and abilities are not easy to assess with the current test format.

*Challenges:*

1) The focus of the AE exam on acquired diseases significantly differs from the focus of the PE/FE exams on congenital anomalies. This may make working from a single content outline framework difficult.
2) There are a variety of practitioners who will take these exams and they might or might not be in specialized roles. The exams cannot cater to each role and will need to focus on knowledge/tasks that are (a) universally applicable and/or (b) necessary for safe and effective practice.
3) The exam is primarily a knowledge exam, with applied knowledge being tested by items that include images. The outlines may need to include fewer task statements and more knowledge statements.
4) The task statements should probably conform to a standardized format: Do action X to object Y [using equipment/technique A] to achieve outcome Z.
5) The current outlines appear to contain too much detail because all diseases/pathologies/anatomy are listed separately. Are there categories of these concepts that can be used instead of listing each individually?

*Specific comments:*

1) Consensus emerged that AE is the best content outline.
    - Stakeholders are ready for a change to the FE outline.
    - Most people start by learning adult, then move into peds (and maybe fetal) but these are considered more specialized.
        - What is considered "entry level" or "minimally qualified" for FE or PE may be at a higher level than for AE.

- Some questions are hard to write to because they may belong on different exams and don't need to retest on them.

2) FE stakeholders will probably be the most resistant to change.
   - FE is a little unique because within the committee there are people on the maternal fetal medicine (MFM) side and the cardiac side, leading to compromises on content.

3) SMEs like the idea of organizing the outlines like a process, with caveats. A content outline with broader domains could be used with subdomains more specific to each exam.
   - A possible issue with this approach is that in FE you are looking at everything every time, but in AE you don't need to go through all the steps every time (still go through normal exam every time).

4) Across specialties, normal anatomy is very similar but the pathology (diseases) and how you employ the technology differs.
   - FE normal anatomy is the most distinct.
   - "In AE you can assume the heart starts "normal," but in peds you never assume anything because you are dealing with congenital disease, you can't even assume the heart will have a normal structure."
     - Approximately 30% of the content on the three exams is similar (e.g., acquiring images, ultrasound) and 70% is different.

5) Some content overlaps across content outlines.
   - The committee may decide to put an item into the area where they need it the most to meet blueprint specifications
     - Get very similar information spread out over multiple categories
     - This makes finding enemy items tough – have to look through the entire bank to find essentially the same item in multiple areas
     - Item writers also find it difficult because they don't know where an item should belong
   - Some of the more general knowledge about measurement techniques belongs on the "physics" exam (the SPI exam).

6) Some content areas are too broad, while others may be too narrow (at least to write multiple items that aren't enemy items).
   - Measurement techniques is the hardest domain to write to; in some cases these tasks/knowledge could be grouped with their pathology.
   - If the content outline was a little less specific in some areas, it would make the gap analysis easier to accomplish
   - SMEs questioned how much of the genetic information examinees need to know about the congenital disorders.

7) There are some areas in the content outlines that have to do with ability, but the test is very much about knowledge. Tasks and abilities are not easy to test in the current format.
   - The more image-based questions there are, the more task/ability based the test can be.

## Appendix C: Review and Revise Existing Content Outline Meeting Summary

**PE Exam Committee Meeting Summary**

*Introduction:*
The HumRRO project team facilitated a meeting with the PE Exam Committee to collect feedback about the current PE content outline. The purpose of the meeting was to (a) learn what the committee members like and dislike about the outline, (b) identify how the outline can be optimized to support exam development or administration activities and tools (e.g., item banking, form assembly), and (c) discuss the integration of a standardized structure for the outline. Prior to the meeting, HumRRO prepared a set of pre-reading materials that provided instructions on performing a critical review of the content outline. Inteleos sent the materials to the committee two weeks prior to the meeting for their review. Notes from the meeting are presented below.

- **Overall Organizational Concerns:** While the committee did not seem especially dissatisfied with the overall organization, they made some comments on what reorganization means. Currently, the exam outline resembles a textbook that both the item writers and candidates use; altering the current structure could impact a candidate's ability to directly translate their textbook learning to the exam. One committee member suggested grouping the content by heart areas/functions (combining normal and abnormal knowledge of those parts). While some agreed with this, others thought it would make writing new questions more difficult.
- **Overlapping Domains**: Committee members agreed that domains 1, 3, and 6 of the outline had significant overlap and may be able to be collapsed/combined. Some believed that test questions could be sorted into different domains because of the overlap.
- **Difficult Topics:** Committee members stated that domains 5 and 6 include topics that are difficult to assess because there is a limited number of possible questions that can be written (i.e., the content is narrow). The members highlighted several challenging subdomains: 1.5.A, PS, and Regurgitation.
- **Terminology:** The outline uses different verbs in the task and knowledge statements. For example, "Knowledge of…" versus "Understanding of". Committee members agreed that "to know" something is to have a recall-level of a topic, while "to understand" something is to be able to apply that knowledge. Knowledge application might be covered by the task statements which means there is redundancy across the statements. Committee members were divided on whether certain medical procedures should be named after the individuals who created/discovered.
- **Assessment Format:** All parties agreed that the current assessment format limited the ability for the exam to assess practical knowledge. Recommendations included making some domains (particularly quantitative) free-response and including more image-based items that assess a test-taker's ability to recognize anatomical, physiological, and pathophysiological features.
- **Missing Content:** Committee members agreed there should be more information regarding contemporary issues like addressing the needs of more diverse patients and infection prevention, but some were concerned with the variable ways that hospitals practically handle these topics.
- **Exam Scope:** Committee members were divided regarding the scope of the exam. Some believed the exam should reflect everything a practitioner should know on the first day of the job (i.e., patient intake, room setup, ultrasound exam, post-exam follow-ups, etc.). Others believed the exam should focus only on the ultrasound exam process and on practitioner competence.

## Appendix D: Remote Expert Panel Meeting Agendas

### Pediatric Echocardiography Practice Analysis Panel Meeting 1 Agenda
Wednesday, June 21, 2023 7:00 PM, ET

**Join Zoom Meeting**
https://inteleos.zoom.us/j/96484843116?pwd=Uk96VTJZd2pGWjVaZWp6NG9DRlZDZz09
**Meeting ID:** 964 8484 3116
**Passcode:** 172518

I. Welcome and Introductions – Kathy Kelly, Chief Assessment Officer
II. Review of Practice Analysis process – Kathy Kelly
III. Review of draft Content Outline and discussion – Cynthia Parshall, PhD, Touchstone Consulting and Panel
IV. Next Steps – Kathy Kelly

### Pediatric Echocardiography Practice Analysis Panel Meeting 2 Agenda
Monday, June 26, 2023 6:00 PM, ET

**Join Zoom Meeting**
https://inteleos.zoom.us/j/91642511800?pwd=b0tMV2lBaE50Q0RVcURFbUtlb1hndz09
**Meeting ID:** 916 4251 1800
**Passcode:** 887146

I. Welcome and Introductions – Kathy Kelly, Chief Assessment Officer
II. Review of draft Content Outline– Cynthia Parshall, PhD, Touchstone Consulting and Panel
III. Review of Knowledge Statements– Cynthia Parshall, PhD, Touchstone Consulting and Panel
IV. Next Steps – Kathy Kelly

## Appendix E: Task Importance Score and Committee Decision

This is the survey that was distributed to RDCS registrants. Cells in column C contain the importance rating for each task and are colored green, yellow, or red. Tasks in the "Green" category have a mean importance score of four or greater. Tasks in the "Yellow" category have a mean importance score of greater than or equal to three and less than four. Tasks in the "Red" category have a mean importance score of less than three (there are no "Red" tasks). The panel's decisions are recorded in column D. Column E contains comments from the panel.

| A. Code | B. Domain & Task | C. Importance | D. Keep? | E. Comment |
|---|---|---|---|---|
| 1 | **Normal Anatomy and Physiology** | | | |
| 1.A.1 | Identify anatomical structures and morphology of the great arteries ~~(e.g., aorta, aortic arch vessels, pulmonary artery, pulmonary trunk, common brachiocephalic trunk)~~ | 4.93 | Yes | Panel Post workshop: eg not necessary |
| 1.A.2 | Identify physiological properties of the great arteries (e.g., spectral Doppler and flow patterns) | 4.88 | Yes | |
| 1.A.3 | Identify anatomical structures and morphology of the systemic and pulmonary veins ~~(e.g., superior and inferior vena cava, innominate vein, coronary sinus, azygos vein, pulmonary veins)~~ | 4.85 | Yes | Panel Post workshop: eg not necessary |
| 1.A.4 | Identify physiological properties of the systemic and pulmonary veins (e.g., spectral Doppler and flow patterns) | 4.75 | Yes | |
| 1.A.5 | Identify anatomical structures and morphology of cardiac valves ~~(e.g., tricuspid, pulmonary, mitral, aortic)~~ | 4.92 | Yes | Panel Post workshop: eg not necessary |
| 1.A.6 | Identify physiological properties of the cardiac valves (e.g., motion, flow patterns) | 4.87 | Yes | |
| 1.A.7 | Identify anatomical structure and morphology of the left and right ventricles of the heart | 4.90 | Yes | |
| 1.A.8 | Identify physiologic function of the left and right ventricles of the heart | 4.86 | Yes | |
| 1.A.9 | Identify anatomical structures and morphology of the left and right atria (e.g., eustachian valve, Chiari network, appendage) | 4.42 | Yes | |
| 1.A.10 | Identify characteristics of normal transitional circulation ~~(e.g., foramen ovale closure, ductus arteriosus closure, decreased pulmonary vascular resistance [PVR], increased systemic vascular resistance [SVR])~~ | 4.81 | Yes | Panel Post workshop: eg not necessary |
| 1.A.11 | Identify anatomy and origin of the coronary arteries | 4.81 | Yes | |
| 1.A.12 | Identify characteristics of abdominal situs ~~solitus~~ | 4.69 | Yes | Panel - "solitus" redundant under normal |
| 2 | **Acquired Heart Disease** | | | |
| 2.A.1 | Identify characteristics of cardiomyopathies | 4.59 | Yes | |
| 2.A.2 | ~~Assess non-compacted cardiomyopathies (e.g., Jenni, Chin)~~ | 4.32 | No | Panel- redundant with 2.a.1 |

| | | | | |
|---|---|---|---|---|
| 2.A.3 | Identify characteristics of pulmonary hypertension ~~(e.g., flattening of the interventricular septum, increased ventricular muscle mass, wall hypertrophy, cavity dilation)~~ | 4.80 | Yes | Panel Post workshop: eg not necessary |
| 2.A.4 | Identify characteristics of systemic hypertension ~~(e.g., ventricular hypertrophy, atrial enlargement)~~ | 4.61 | Yes | Panel Post workshop: eg not necessary |
| 2.A.5 | Assess pericardial and pleural abnormalities (e.g., effusions, tamponade, pericardial thickening) | 4.75 | Yes | Panel: added to include pleural effusions |
| 2.A.6 | ~~Assess pleural effusions~~ | 3.92 | No | Panel: redundant w/2A.5 |
| 2.A.7 | Identify characteristics of acquired coronary artery abnormalities (e.g., Kawasaki disease) | 4.76 | Yes | |
| 2.A.8 | Identify characteristics of infective endocarditis ~~(e.g., valvular regurgitation, vegetations, abscesses, aneurysms, perforations, fistulas)~~ | 4.65 | Yes | Panel Post workshop: eg not necessary |
| 2.A.9 | Identify characteristics of ~~intra~~cardiac ~~and vascular~~ thrombi | 4.57 | Yes | Panel: Should be more general |
| 2.A.10 | Identify characteristics of functional abnormalities associated with drug toxicity (e.g., ~~Adriamycin~~ chemotherapy) | 4.36 | Yes | Panel: Adriamycin is brand |
| 2.A.11 | Identify characteristics of rheumatic ~~fever~~ heart disease | 4.34 | Yes | |
| 2.A.12 | ~~Identify characteristics of lesions associated with gestational or maternal diabetes~~ | 4.36 | No | Panel - too specific- included in above |
| 3 | **Congenital Anomalies** | | | |
| 3.A.1 | Identify characteristics of aortic arch anomalies | 4.89 | Yes | |
| 3.A.2 | Identify characteristics of vascular rings and slings ~~(e.g., double aortic arch, right arch with aberrant subclavian artery, pulmonary sling)~~ | 4.73 | Yes | Panel Post workshop: eg not necessary |
| 3.A.3 | Identify characteristics of conotruncal defects ~~(e.g., tetralogy of Fallot [TOF], double outlet right ventricle [DORV], truncus arteriosus, aortopulmonary [AP] window)~~ | 4.93 | Yes | Panel Post workshop: eg not necessary |
| 3.A.4 | Assess anomalies of the aortic valve | 4.85 | Yes | Panel - Move above 3.a.9 |
| 3.A.5 | Assess ventricular outflow tract anomalies | 4.83 | Yes | |
| 3.A.6 | Identify characteristics of atrioventricular and ventriculoarterial connection anomalies ~~(e.g., dextro-transposition of the great arteries [d-TGA], levo-transposition of the great arteries [l-TGA], physiologically corrected TGA)~~ | 4.92 | Yes | Panel Post workshop: eg not necessary |
| 3.A.7 | Identify characteristics of anomalies of the pulmonary veins ~~(e.g., partially and totally anomalous connection/drainage, pulmonary vein stenosis)~~ | 4.87 | Yes | Panel Post workshop: eg not necessary |
| 3.A.8 | Assess anomalies of the pulmonary arteries ~~(e.g., supravalvar and peripheral stenosis, dilated arteries, discontinuous arteries)~~ | 4.84 | Yes | Panel Post workshop: eg not necessary |

| | | | | |
|---|---|---|---|---|
| 3.A.9 | Assess anomalies of the pulmonic valve | 4.77 | Yes | |
| 3.A.10 | Assess anomalies of the mitral valve | 4.80 | Yes | |
| 3.A.11 | Assess anomalies of the tricuspid valve | 4.77 | Yes | |
| 3.A.12 | Identify characteristics of patent ductus arteriosus and aortopulmonary collaterals | 4.79 | Yes | |
| 3.A.13 | Identify characteristics of atrioventricular canal defects | 4.88 | Yes | |
| 3.A.14 | Identify characteristics of atrial and ventricular septal defects | 4.86 | Yes | |
| 3.A.15 | Identify characteristics of abnormalities of the coronary artery (e.g., anomalous origin and course, sinusoids, fistulae) | 4.74 | Yes | Panel- add for clarification |
| 3.A.16 | Identify characteristics of anomalies of abdominal and cardiac situs/position | 4.71 | Yes | |
| 3.A.17 | Identify characteristics of anomalies of the systemic venous system | 4.66 | Yes | |
| 3.A.18 | Identify characteristics of cardiac tumors | 4.52 | Yes | |
| 3.A.19 | Identify characteristics of cor triatriatum | 4.64 | Yes | |
| 3.A.20 | Assess single ventricle anomalies and pathophysiology | 4.87 | Yes | |
| 3.A.21 | Identify characteristics of lesions associated with connective tissue disorders (e.g., Marfan syndrome, Ehlers-Danlos syndrome, Loeys-Dietz syndrome) | 4.69 | Yes-Move | Panel -Move to domain 2 |
| 3.A.22 | Identify characteristics of cardiac pathologies associated with genetic disorders | 4.60 | Yes | |
| 4 | **Postoperative (surgically corrected/palliated) Anatomy** | | | |
| 4.A.1 | Identify characteristics of tetralogy of Fallot repair | 4.76 | Yes | |
| 4.A.2 | Identify characteristics of valve repair/replacement | 4.69 | Yes | |
| 4.A.3 | Identify characteristics of surgical repair for aortic arch anomalies | 4.70 | Yes | |
| 4.A.4 | Identify characteristics of atrial and ventricular septal defect surgical repair | 4.68 | Yes | |
| 4.A.5 | Identify characteristics of shunt closure devices ~~(e.g., atrial septal defect, patent ductus arteriosus, and ventricular septal defect devices/coils)~~ | 4.69 | Yes | Panel Post workshop: eg not necessary |
| 4.A.6 | Identify characteristics of arterial switch operation | 4.73 | Yes | |
| 4.A.7 | Identify characteristics of atrial switch operation (e.g., Mustard, Senning) | 4.60 | Yes | |
| 4.A.8 | Identify characteristics of post-interventional valvular and vascular procedures (e.g., balloon, stent, transcatheter ~~aortic~~ valve replacement ~~[TAVR~~]) | 4.61 | Yes | Panel: don't need aortic or TAVR |
| 4.A.9 | Identify characteristics of modified Blalock-Thomas-Taussig shunt or central shunt | 4.68 | Yes | |
| 4.A.10 | Identify characteristics of single ventricle staged palliation ~~the Norwood staged procedure and modifications (e.g., Fontan with and without fenestration, Glenn)~~ | 4.72 | Yes | |
| 4.A.11 | Identify characteristics of the Ross procedure | 4.66 | Yes | |
| 4.A.12 | Identify characteristics of repair of total/partial anomalous pulmonary venous connection | 4.68 | Yes | |
| 4.A.13 | Identify characteristics of pulmonary artery banding | 4.62 | Yes | |
| 4.A.14 | Identify characteristics of Rastelli repair | 4.65 | Yes | |

| | | | | |
|---|---|---|---|---|
| 4.A.15 | Identify implantable devices and lines (e.g., catheters, pacemaker/defibrillator leads) | 4.32 | Yes | |
| 4.A.16 | Identify characteristics of cardiac transplantation and rejection ~~(e.g., ventricular remodeling, edema, fractional shortening, myocardial stiffness)~~ | 4.42 | Yes | Panel: eg not necessary |
| 5 | **Performing the Exam** | | | |
| 5.A.1 | Obtain a parasternal view ~~(i.e., short axis, long axis, right, high left)~~ | 4.93 | Yes | Panel: i.e. not necessary |
| 5.A.2 | Obtain a suprasternal view ~~(i.e., short axis, long axis)~~ | 4.90 | Yes | Panel: i.e. not necessary |
| 5.A.3 | Obtain an apical view ~~(i.e., two-chamber, three-chamber/long axis, four-chamber with apex down, five-chamber)~~ | 4.89 | Yes | Panel: i.e. not necessary |
| 5.A.4 | Obtain a subcostal view ~~(i.e., sagittal/long axis, coronal/long axis)~~ | 4.91 | Yes | Panel: i.e. not necessary |
| 5.A.5 | Adjust equipment settings to optimize image quality and Doppler information | 4.83 | Yes | |
| 5.A.6 | Select appropriate transducer(s) based on patient size, window, and modality | 4.84 | Yes | |
| 5.A.7 | Practice universal precautions and proper patient care | 4.83 | Yes | |
| 5.A.8 | Interrogate the aortic arch using color and spectral Doppler | 4.91 | Yes | |
| 5.A.9 | Interrogate the atrial and ventricular septum using color Doppler | 4.88 | Yes | |
| 5.A.10 | Assess physiology of ventricular septal defects ~~gradients (e.g., assess and calculate maximal pressure gradient across the defect, estimate degree of shunt using the Qp/Qs ratio, measure peak jet velocity across the defect)~~ | 4.68 | Yes | Panel: eg not necessary |
| 5.A.11 | Assess physiology of atrial septal defects ~~shunting gradients (e.g., assess and calculate maximal pressure gradient across the defect, calculate mean and diastolic pulmonary artery pressure)~~ | 4.55 | Yes | Panel: eg not necessary |
| 5.A.12 | Calculate maximal pressure gradients using the modified Bernoulli equation | 4.58 | Yes | |
| 5.A.13 | Interrogate pulmonary venous return using color and spectral Doppler | 4.77 | Yes | |
| 5.A.14 | Interrogate the pulmonary artery and branches using color and spectral Doppler | 4.83 | Yes | |
| 5.A.15 | Assess right ~~ventricular~~ heart pressure ~~using tricuspid and pulmonary regurgitant jet velocities~~ | 4.80 | Yes | Panel: more general |
| 5.A.16 | Interrogate systemic venous return using color and spectral Doppler | 4.68 | Yes | |
| 5.A.17 | Assess ventricular regional wall motion using two-dimensional ~~or M-mode~~ imaging | 4.61 | Yes | Panel: M mode not necessary |
| 5.A.18 | ~~Assess myocardial deformation using Doppler or two-dimensional with speckle tracking imaging methods (e.g., quantify strain and strain rate; evaluate ventricular relaxation, twist, and untwist)~~ | 3.96 | No | panel tweaked 27 so now includes this |
| 5.A.19 | Demonstrate echocardiographic findings at specific times during the electrocardiogram (cardiac) cycle | 4.41 | Yes | |
| 5.A.20 | Measure chamber sizes and wall thickness using two-dimensional or M-mode imaging methods | 4.48 | Yes | Panel: add M Mode |

| | | | | |
|---|---|---|---|---|
| 5.A.21 | ~~Measure chamber sizes and wall thickness using M-mode~~ | 4.36 | No | panel added m mode to 20 |
| 5.A.22 | Calculate fractional shortening using two-dimensional or M-mode imaging | 4.43 | Yes | |
| 5.A.23 | Perform linear measurements of cardiac structures using two-dimensional imaging methods | 4.49 | Yes | Panel: added to clarify |
| 5.A.24 | Calculate ejection fraction (e.g., biplane Simpson, 5/6 area-length [bullet]~~, 2-D, M-mode~~) | 4.51 | Yes-Move | Panel - Move under 22 |
| 5.A.25 | Calculate indices of diastolic function (e.g., E/A ratio, E/E' ratio, mitral valve inflow pattern, pulmonary venous flow pattern) | 4.23 | Yes | |
| 5.A.26 | Correlate measurements to Z-score ~~(e.g., Pettersen, Boston)~~ | 4.50 | Yes | Panel: eg not necessary |
| 5.A.27 | Utilize advanced ultrasound techniques (e.g., myocardial strain, three-dimensional imaging, ultrasound enhancing agents, agitated saline studies) | 3.54 | Yes | Yes-Important for future |

## Appendix F: Demographic Analysis

Figure 1. 2023 **PE Population** Gender Identification

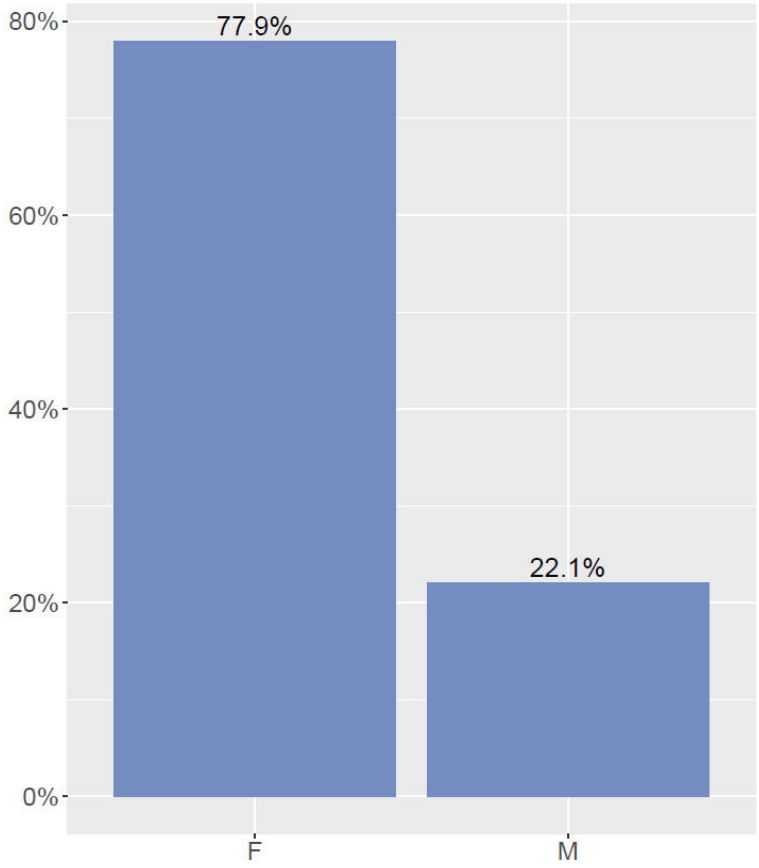



Figure 2. 2023 **PE Survey Respondents** Gender Identification

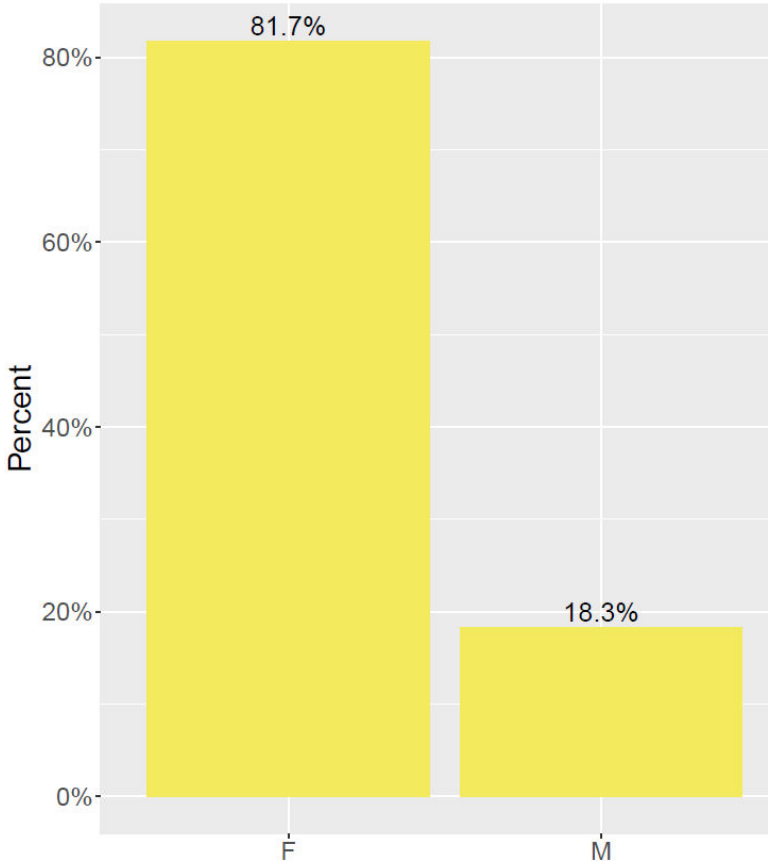



Figure 3. **2015 PE Survey Respondents** Gender Identification

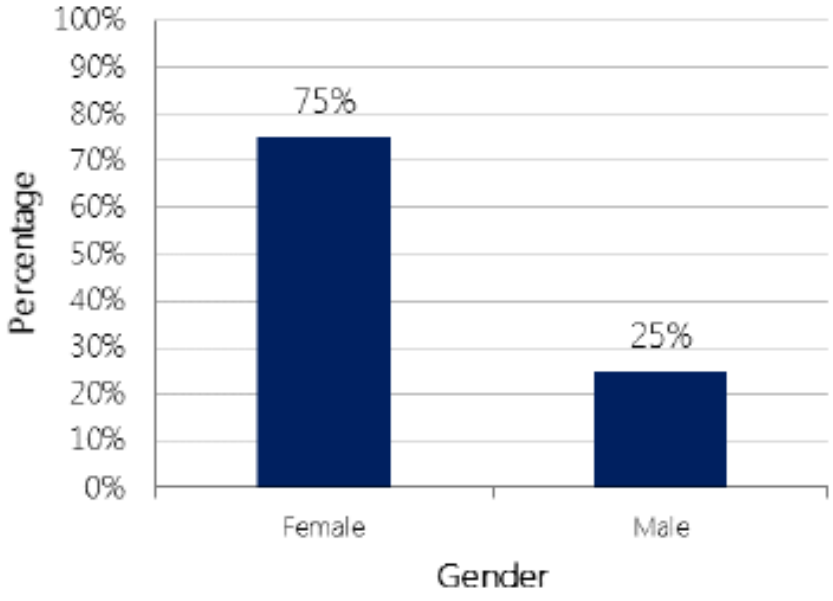


Figure 4. 2023 **PE Population** Age

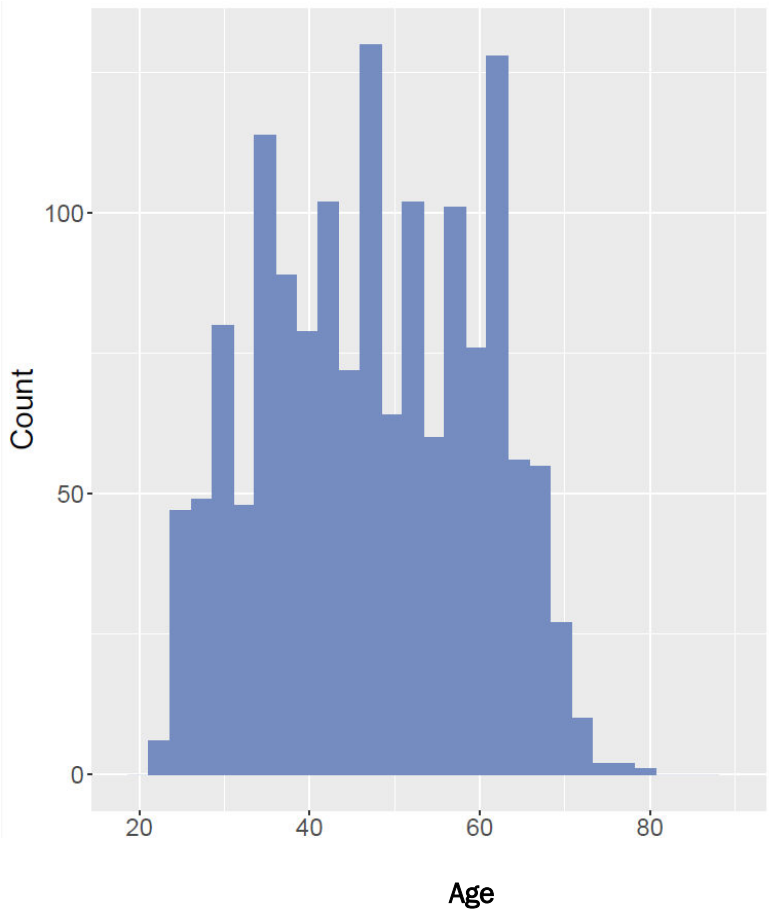



Figure 5. 2023 **PE Survey Respondents** Age

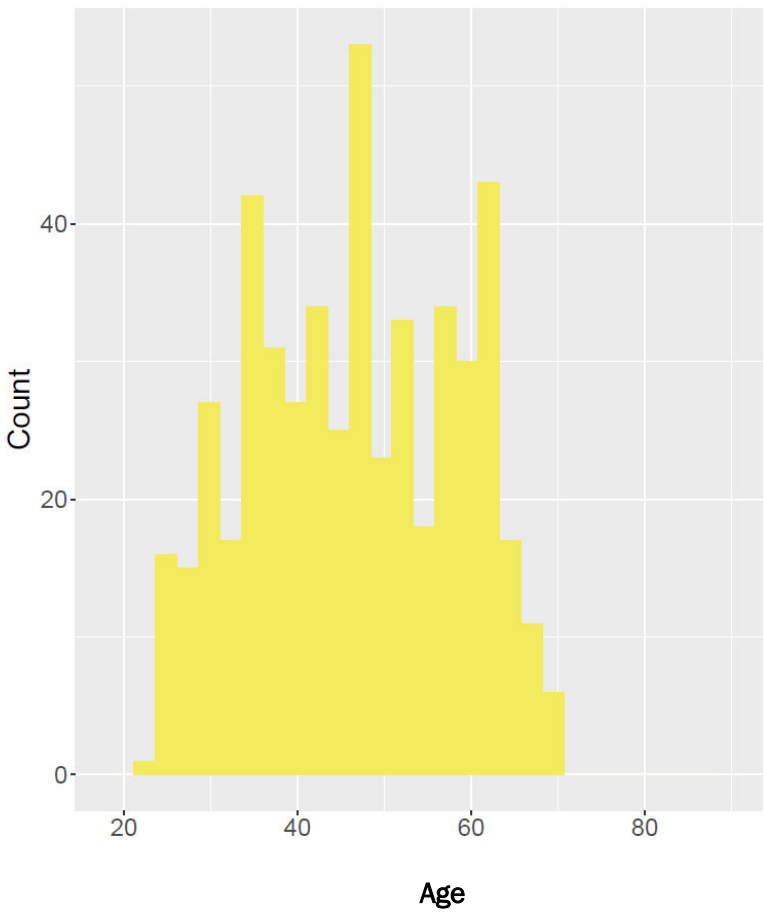


Figure 6. 2023 **PE Population Country** of Residence

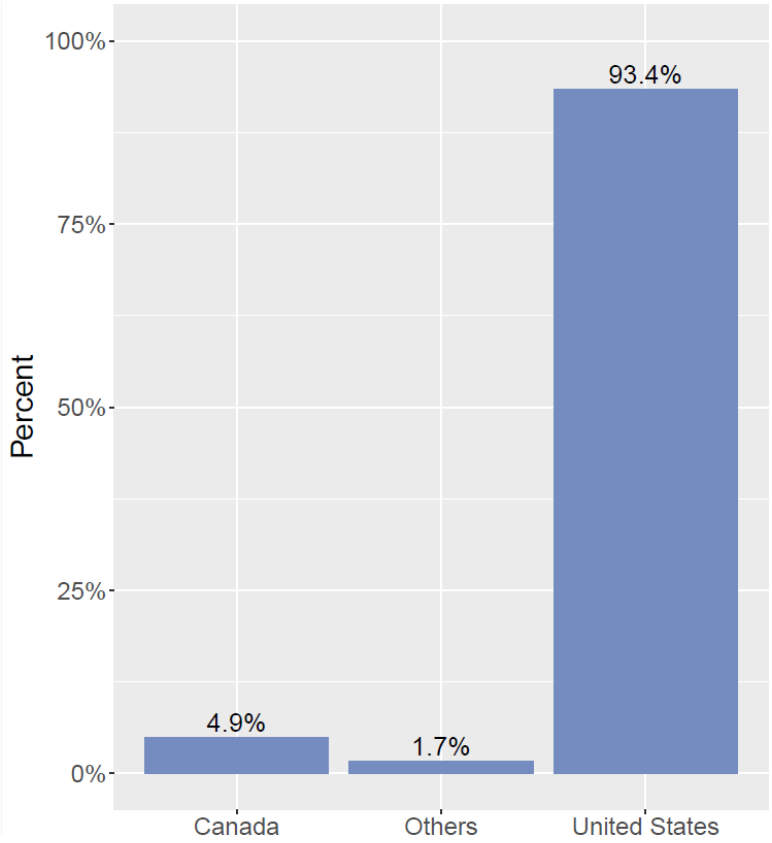
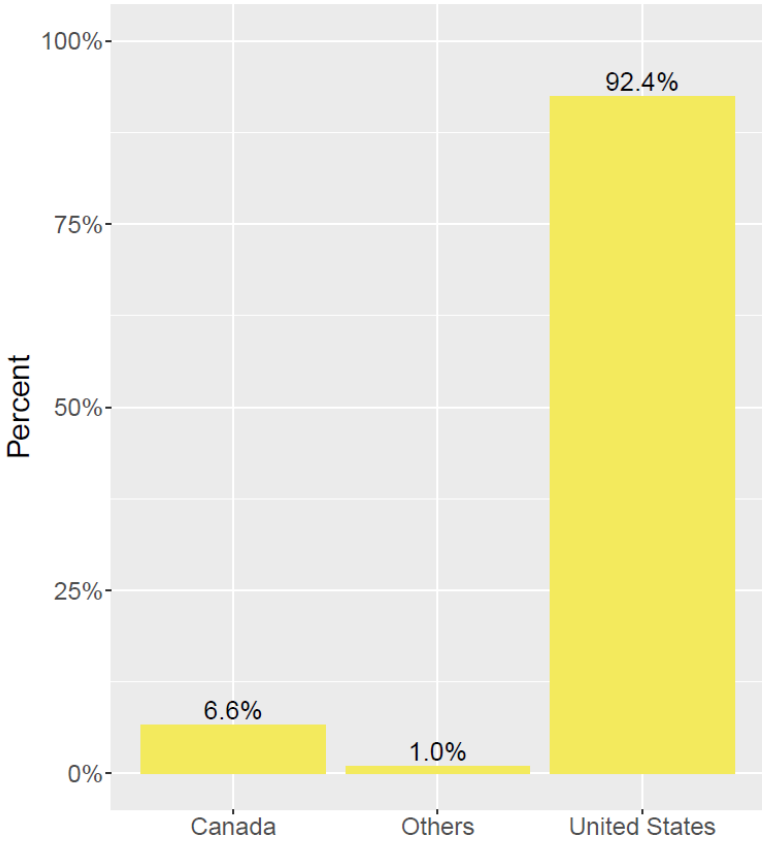



Figure 7. 2023 **PE Survey Respondents Country** of Residence




In 2015 about 7% of the survey respondents were from outside the US. Which is similar to both the current population and the 2023 survey respondents.

Figure 7. 2023 **PE Population** U.S. Census Region

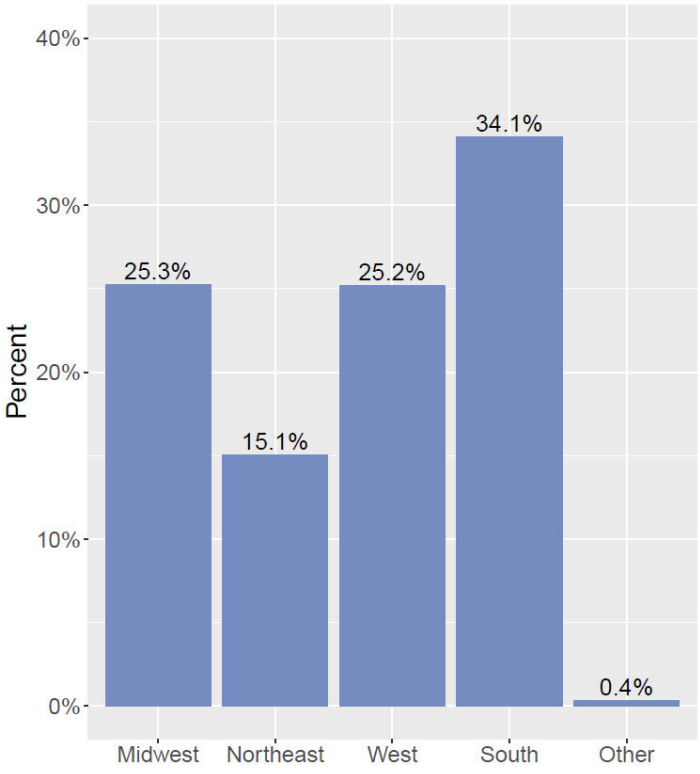



Figure 8. 2023 **PE Survey Respondents** U.S. Census Region

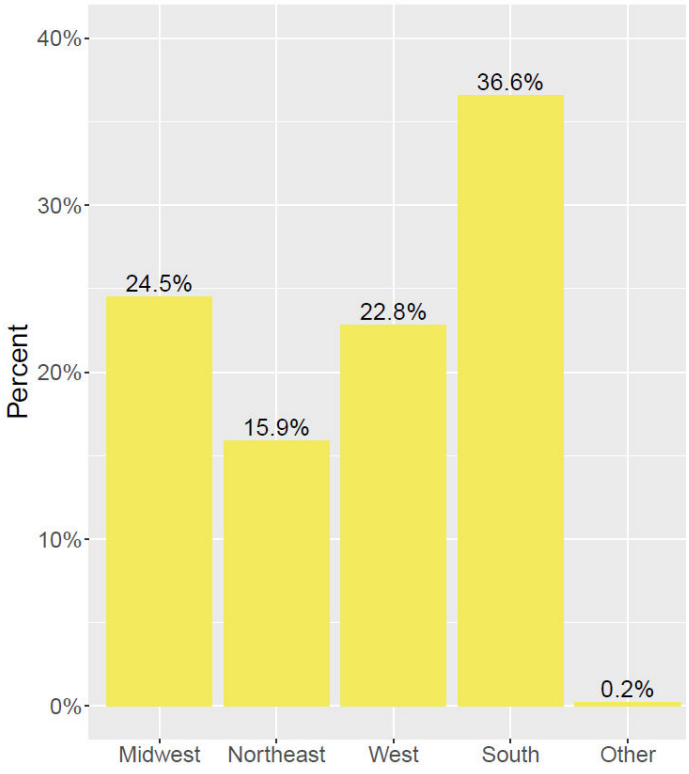



Figure 9. **2015 PE Survey Respondents** U.S. Census Region

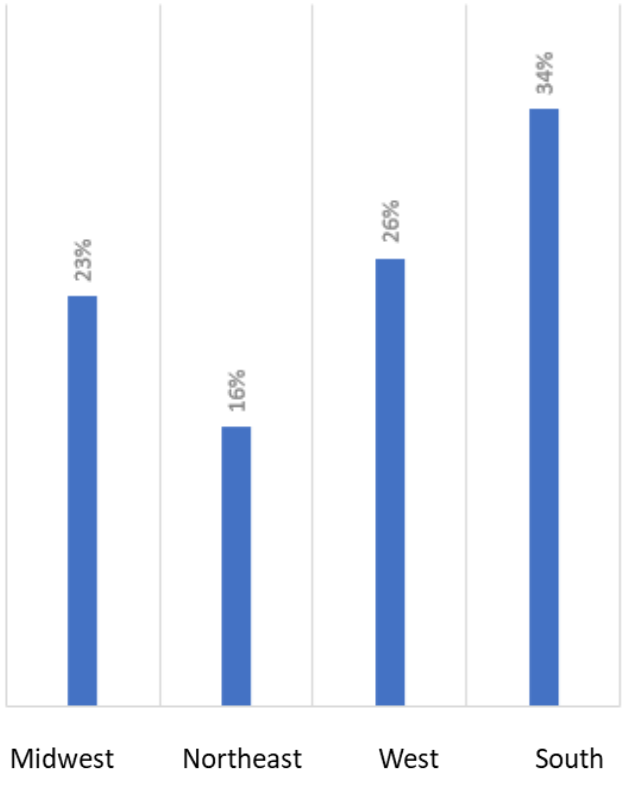


Figure 10. 2023 **PE Population** Primary Job Function

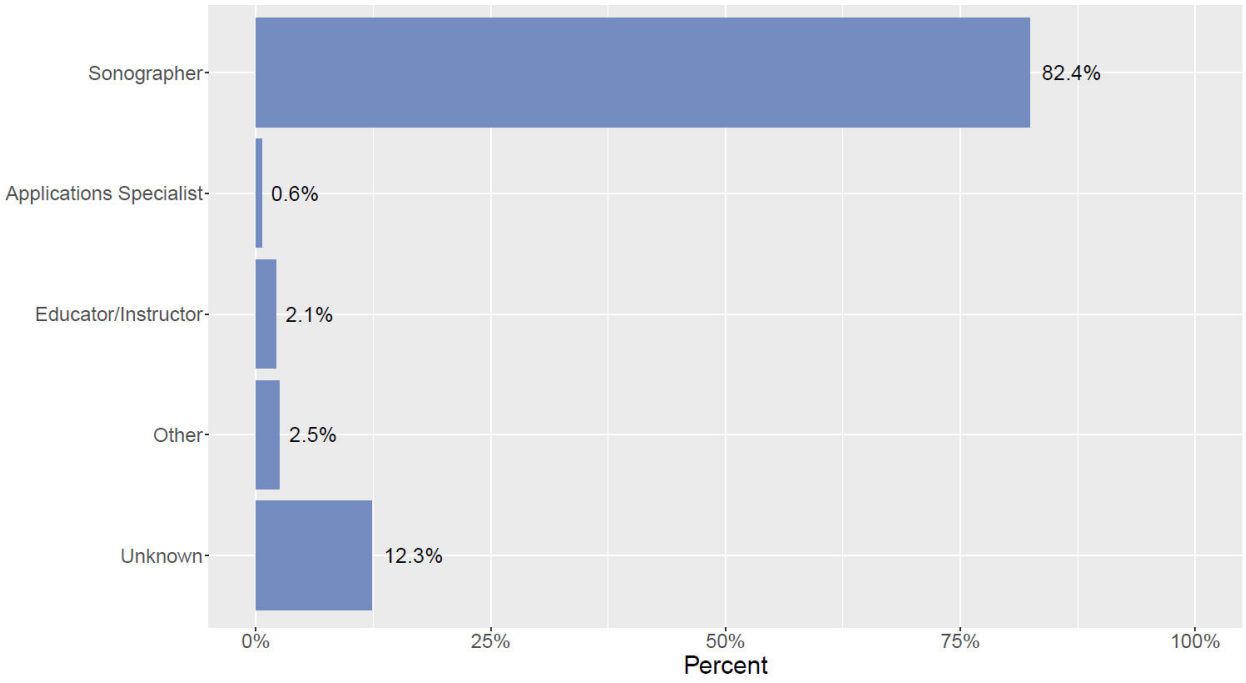



Figure 11. 2023 **PE Survey Respondents** Primary Job Function

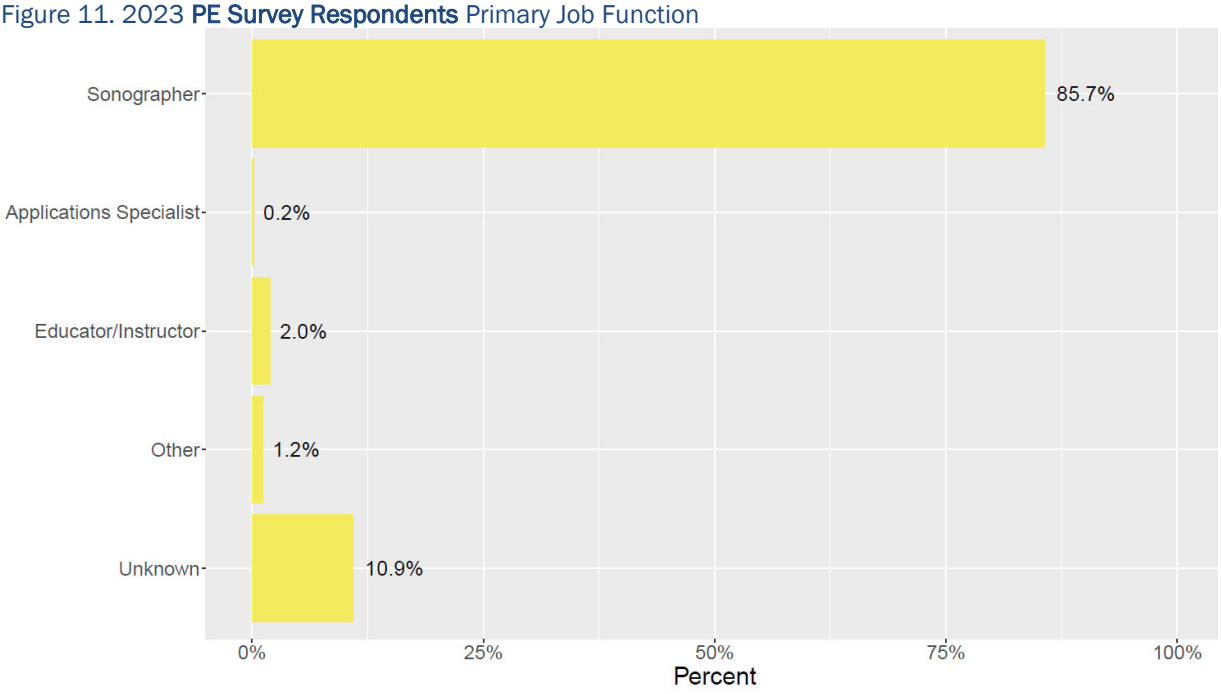


Figure 12. 2023 **PE Survey Respondents** Years Performing Pediatric Echocardiography Ultrasound

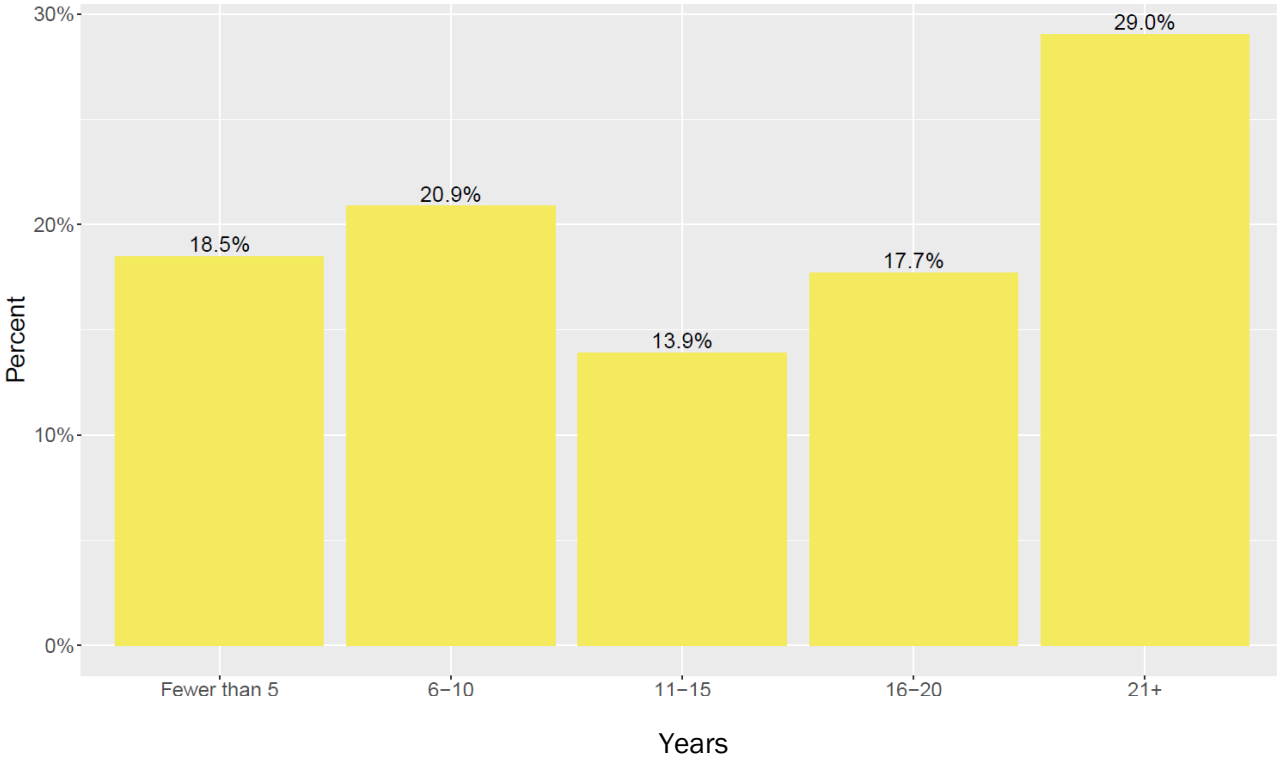



Figure 13. 2015 **PE Survey Respondents** Years Performing Pediatric Echocardiography Ultrasound

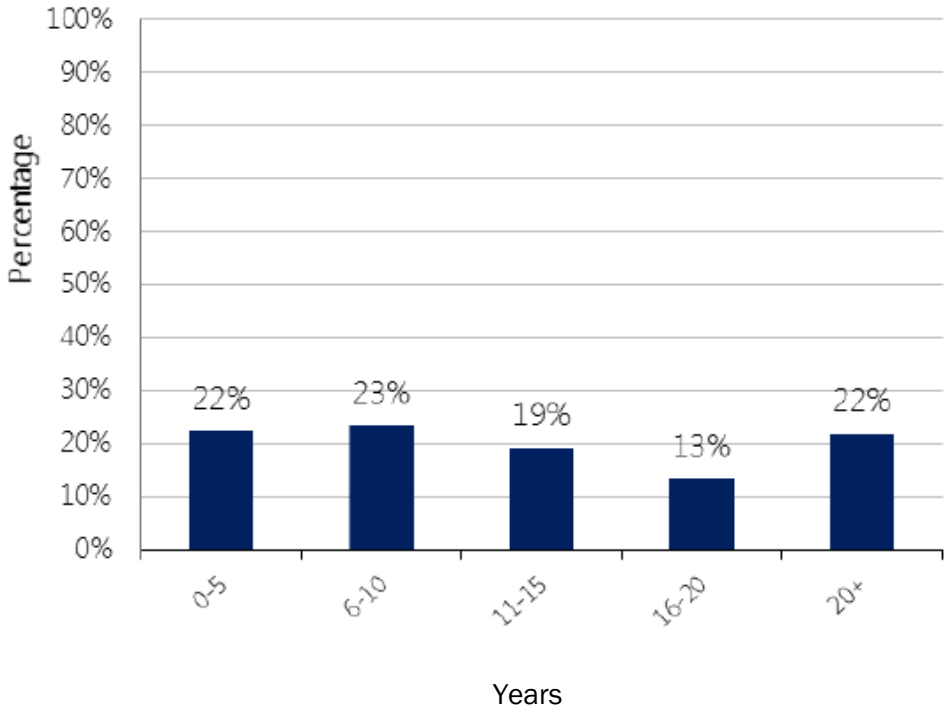


Figure 14. 2023 **PE Survey Respondents** PE examinations per month

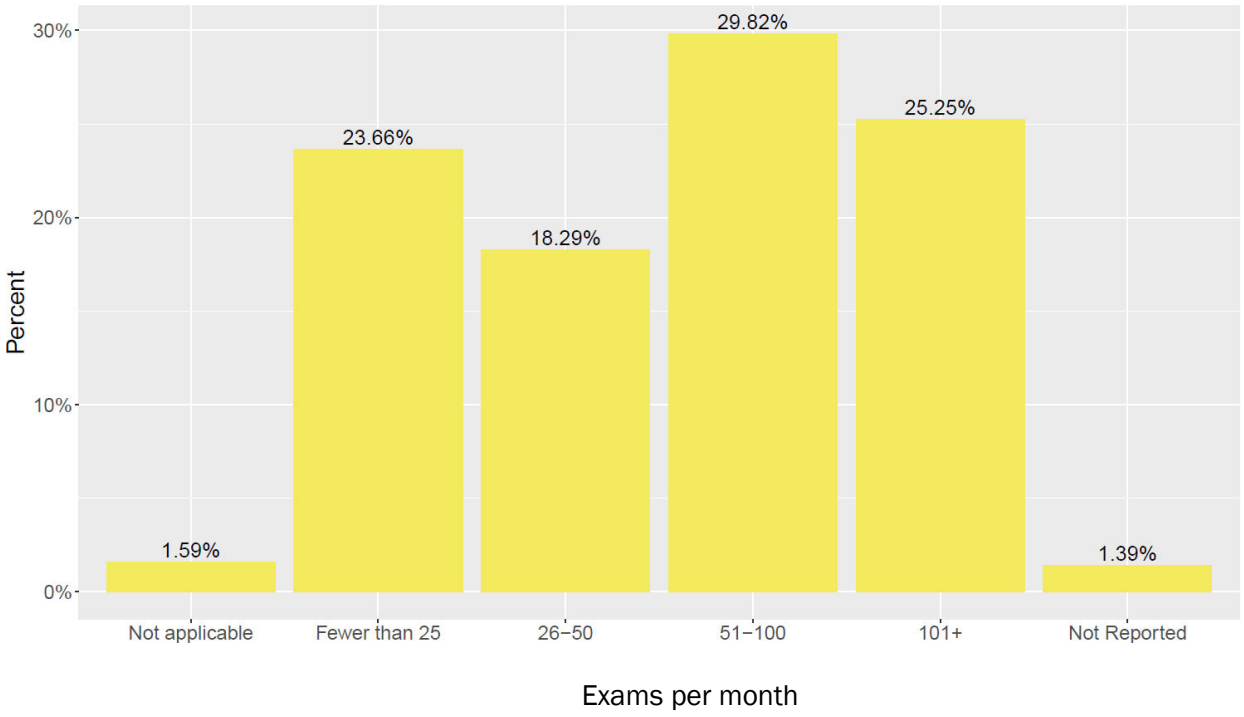



Figure 15. **2015 PE Survey Respondents** PE examinations per month

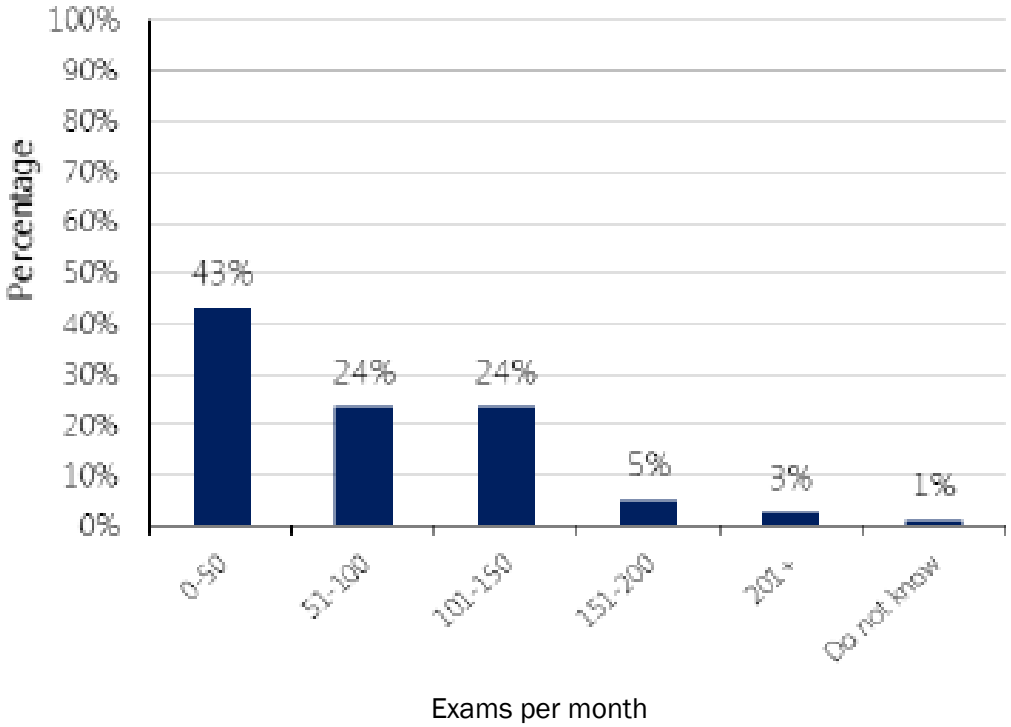


Figure 16. 2023 **PE Survey Respondents** Work Settings

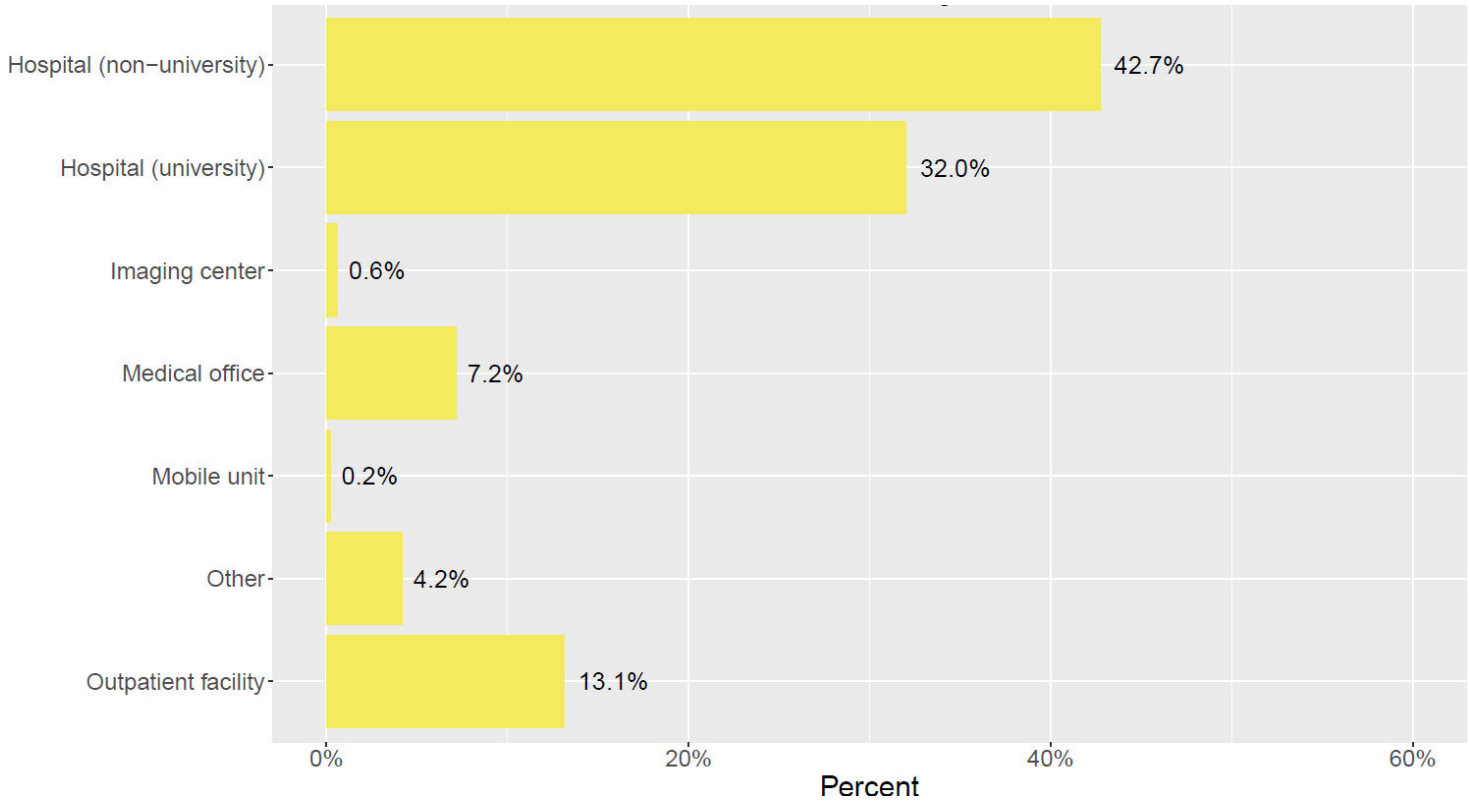
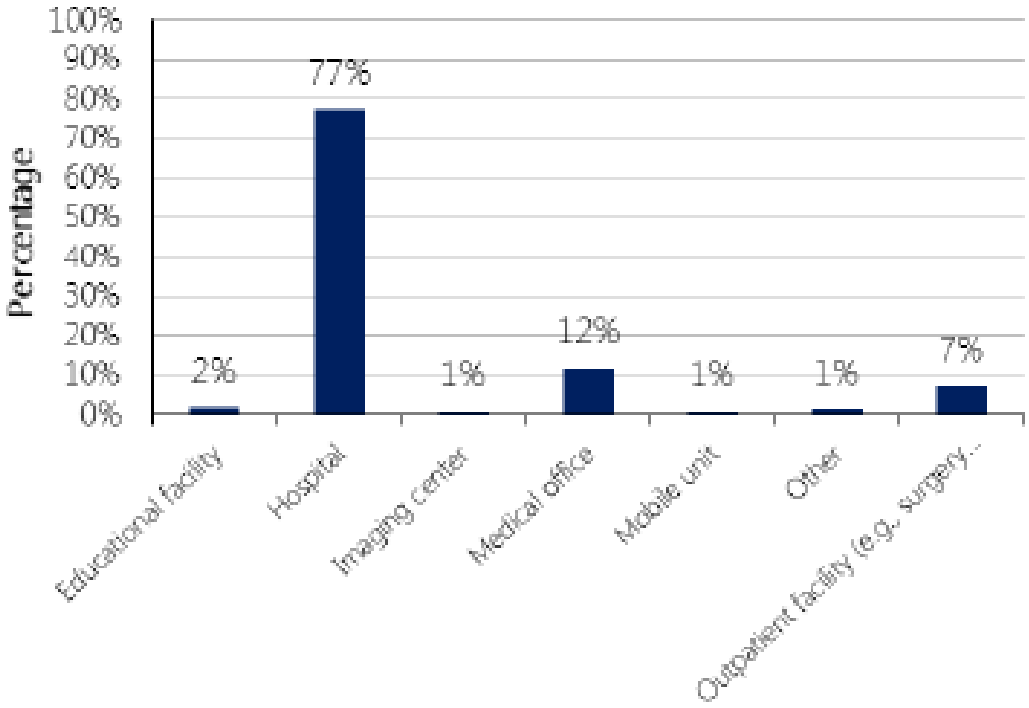



Figure 17. **2015 PE Survey Respondents** Work Settings



## Appendix G: Expert Panel In-Person Workshop Agenda

### PE Practice Analysis & Item Development Workshop
September 15 – 16, 2023
Seattle, WA

Friday, September 15th

| Topics | Description | Facilitator | Time |
|---|---|---|---|
| Breakfast | | | 8:00-9:00 AM |
| Introductions/Ice Breaker | Welcome/Introductions<br>Ice breaker | Alaina Cunningham | 9:00-9:15 |
| Practice Analysis | Overview<br>Key insights and findings<br>Weighting Activity | Sarah Pelter | 9:15-10:30 |
| Break | | | 10:30 - 10:45 AM |
| Group Activity | Develop Knowledge, Skills, and Abilities<br>Wrap-up Practice Analysis | Sarah Pelter | 10:45-12:30 PM |
| Lunch | | | 12:30-1:30 PM |
| Group Activity | Item writing training<br>Item writing | Alaina Cunningham | 1:30-3:00 PM |
| Break | | | 3:00-3:15 PM |
| Group Activity | Item writing | Alaina Cunningham | 3:15-5 PM |
| Dinner | | | 6:00-8:00 PM |

Saturday, September 16th

| Topics | Description | Facilitator | Time |
|---|---|---|---|
| Breakfast | | | 8:00-9:00 AM |
| Group Activity | Continue item writing and review | Alaina Cunningham | 9:00-10:30 AM |
| Break | | | 10:30 - 10:45 AM |
| Group Activity | Continue item writing and review | Alaina Cunningham | 10:45-12:30 PM |
| Lunch | | | 12:30-1:30 PM |
| Group Activity | Continue item writing and review | Alaina Cunningham | 1:30-3:00 PM |

## Appendix H: Final Content Outline and KSAs

### Pediatric Echocardiography Examination Content Outline
**(Outline Summary)**

| # | Domain | Percentage |
|---|---|---|
| 1 | **Normal Anatomy and Physiology** | **15%** |
| 2 | **Acquired Heart Disease** | **12%** |
| 3 | **Congenital Anomalies** | **25%** |
| 4 | **Postoperative (surgically corrected/palliated) Anatomy** | **19%** |
| 5 | **Performing the Exam** | **29%** |

**(Detailed Outline)**

| 1. | **Normal Anatomy and Physiology 15%** |
|---|---|
| 1.A.1. | Identify anatomical structures and morphology of the great arteries |
| 1.A.2. | Identify physiological properties of the great arteries (e.g., spectral Doppler and flow patterns) |
| 1.A.3. | Identify anatomical structures and morphology of the systemic and pulmonary veins |
| 1.A.4. | Identify physiological properties of the systemic and pulmonary veins (e.g., spectral Doppler and flow patterns) |
| 1.A.5. | Identify anatomical structures and morphology of cardiac valves |
| 1.A.6. | Identify physiological properties of the cardiac valves (e.g., motion, flow patterns) |
| 1.A.7. | Identify anatomical structure and morphology of the left and right ventricles of the heart |
| 1.A.8. | Identify physiologic function of the left and right ventricles of the heart |
| 1.A.9. | Identify anatomical structures and morphology of the left and right atria (e.g., eustachian valve, Chiari network, appendage) |
| 1.A.10. | Identify characteristics of normal transitional circulation |
| 1.A.11. | Identify anatomy and origin of the coronary arteries |
| 1.A.12. | Identify characteristics of abdominal situs |

| 2. | Acquired Heart Disease 12% |
|---|---|
| 2.A.1. | Identify characteristics of cardiomyopathies |
| 2.A.2. | Identify characteristics of pulmonary hypertension |
| 2.A.3. | Identify characteristics of systemic hypertension |
| 2.A.4. | Assess pericardial and pleural abnormalities |
| 2.A.5. | Identify characteristics of acquired coronary artery abnormalities (e.g., Kawasaki disease) |
| 2.A.6. | Identify characteristics of infective endocarditis |
| 2.A.7. | Identify characteristics of cardiac thrombi |
| 2.A.8. | Identify characteristics of functional abnormalities associated with drug toxicity (e.g., chemotherapy) |
| 2.A.9. | Identify characteristics of lesions associated with connective tissue disorders (e.g., Marfan syndrome, Ehlers-Danlos syndrome, Loeys-Dietz syndrome) |
| 2.A.10. | Identify characteristics of rheumatic heart disease |
| **3.** | **Congenital Anomalies 25%** |
| 3.A.1 | Identify characteristics of aortic arch anomalies |
| 3.A.2 | Identify characteristics of vascular rings and slings |
| 3.A.3 | Identify characteristics of conotruncal defects |
| 3.A.4 | Assess ventricular outflow tract anomalies |
| 3.A.5 | Identify characteristics of atrioventricular and ventriculoarterial connection anomalies |
| 3.A.6 | Identify characteristics of anomalies of the pulmonary veins |
| 3.A.7 | Assess anomalies of the pulmonary arteries |
| 3.A.8 | Assess anomalies of the aortic valve |
| 3.A.9 | Assess anomalies of the pulmonic valve |
| 3.A.10 | Assess anomalies of the mitral valve |

| | |
|---|---|
| 3.A.11 | Assess anomalies of the tricuspid valve |
| 3.A.12 | Identify characteristics of patent ductus arteriosus and aortopulmonary collaterals |
| 3.A.13 | Identify characteristics of atrioventricular canal defects |
| 3.A.14 | Identify characteristics of atrial and ventricular septal defects |
| 3.A.15 | Identify characteristics of abnormalities of the coronary artery (e.g., anomalous origin and course, sinusoids, fistulae) |
| 3.A.16 | Identify characteristics of anomalies of abdominal and cardiac situs/position |
| 3.A.17 | Identify characteristics of anomalies of the systemic venous system |
| 3.A.18 | Identify characteristics of cardiac tumors |
| 3.A.19 | Identify characteristics of cor triatriatum |
| 3.A.20 | Assess single ventricle anomalies and pathophysiology |
| 3.A.21 | Identify characteristics of cardiac pathologies associated with genetic disorders |
| **4.** | **Postoperative (surgically corrected/palliated) Anatomy 19 %** |
| 4.A.1 | Identify characteristics of tetralogy of Fallot repair |
| 4.A.2 | Identify characteristics of valve repair/replacement |
| 4.A.3 | Identify characteristics of surgical repair for aortic arch anomalies |
| 4.A.4 | Identify characteristics of atrial and ventricular septal defect surgical repair |
| 4.A.5 | Identify characteristics of shunt closure devices |
| 4.A.6 | Identify characteristics of arterial switch operation |
| 4.A.7 | Identify characteristics of atrial switch operation (e.g., Mustard, Senning) |
| 4.A.8 | Identify characteristics of post-interventional valvular and vascular procedures (e.g., balloon, stent, transcatheter valve replacement) |
| 4.A.9 | Identify characteristics of modified Blalock-Thomas-Taussig shunt or central shunt |
| 4.A.10 | Identify characteristics of single ventricle staged palliation |

| | |
|---|---|
| 4.A.11 | Identify characteristics of the Ross procedure |
| 4.A.12 | Identify characteristics of repair of total/partial anomalous pulmonary venous connection |
| 4.A.13 | Identify characteristics of pulmonary artery banding |
| 4.A.14 | Identify characteristics of Rastelli repair |
| 4.A.15 | Identify implantable devices and lines (e.g., catheters, pacemaker/defibrillator leads) |
| 4.A.16 | Identify characteristics of cardiac transplantation and rejection |
| **5.** | **Performing the Exam 29%** |
| 5.A.1 | Obtain a parasternal view |
| 5.A.2 | Obtain a suprasternal view |
| 5.A.3 | Obtain an apical view |
| 5.A.4 | Obtain a subcostal view |
| 5.A.5 | Adjust equipment settings to optimize image quality and Doppler information |
| 5.A.6 | Select appropriate transducer(s) based on patient size, window, and modality |
| 5.A.7 | Practice universal precautions and proper patient care |
| 5.A.8 | Interrogate the aortic arch using color and spectral Doppler |
| 5.A.9 | Interrogate the atrial and ventricular septum using color Doppler |
| 5.A.10 | Assess physiology of ventricular septal defects |
| 5.A.11 | Assess physiology of atrial septal defects |
| 5.A.12 | Calculate maximal pressure gradients using the modified Bernoulli equation |
| 5.A.13 | Interrogate pulmonary venous return using color and spectral Doppler |
| 5.A.14 | Interrogate the pulmonary artery and branches using color and spectral Doppler |
| 5.A.15 | Assess right heart pressure |

| | |
|---|---|
| 5.A.16 | Interrogate systemic venous return using color and spectral Doppler |
| 5.A.17 | Assess ventricular regional wall motion using two-dimensional imaging |
| 5.A.18 | Demonstrate echocardiographic findings at specific times during the electrocardiogram (cardiac) cycle |
| 5.A.19 | Measure chamber sizes and wall thickness using two-dimensional or M-mode imaging methods |
| 5.A.20 | Calculate fractional shortening using two-dimensional or M-mode imaging |
| 5.A.21 | Calculate ejection fraction (e.g., biplane Simpson, 5/6 area-length [bullet]) |
| 5.A.22 | Perform linear measurements of cardiac structures using two-dimensional imaging methods |
| 5.A.23 | Calculate indices of diastolic function (e.g., E/A ratio, E/E' ratio, mitral valve inflow pattern, pulmonary venous flow pattern) |
| 5.A.24 | Correlate measurements to Z-score |
| 5.A.25 | Utilize advanced ultrasound techniques (e.g., myocardial strain, three-dimensional imaging, ultrasound enhancing agents, agitated saline studies) |

| **Knowledge, Skills, and Abilities:**<br>*The following is a list of the foundational knowledge, skills, and abilities required to complete the tasks listed in the content outline.* |
|---|
| Understand hemodynamics and physiology of normal and abnormal hearts |
| Identification of variations of normal anatomy |
| Identification of transitional newborn physiology |
| Understand progression of disease states in congenital and acquired heart disease |
| Ability to recognize structural heart disease |
| Knowledge of pediatric specific anomalies |
| Knowledge of congenital heart lesions and interventions |
| Knowledge of genetic syndromes and associated cardiac findings |
| Knowledge of expected outcomes after interventions |
| Knowledge of additional pediatric/lesion specific imaging views/techniques |
| Knowledge of equipment and imaging settings |
| Troubleshooting common challenges in obtaining images |
| Knowledge of optimization of ergonomics and environment |

| |
|---|
| Knowledge of universal precautions |
| Ability to make patients and guardians feel comfortable/calming techniques |
| Ability to have situational awareness while scanning a patient |
| Knowledge of critical findings and the appropriate response |
| Knowledge of the published guidelines for performance and quantification of a pediatric echocardiogram including Z-scores |
| Ability to follow standardized methods of assessment |
| Understand hemodynamics and physiology of normal and abnormal hearts |