

Original Article

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The development and efficacy of a paediatric cardiology fellowship online preparatory course

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Abstract

Background: The transition from residency to paediatric cardiology fellowship is challenging due to the new knowledge and technical skills required. Online learning can be an effective didactic modality that can be widely accessed by trainees. We sought to evaluate the effectiveness of a paediatric cardiology Fellowship Online Preparatory Course prior to the start of fellowship. **Methods:** The Online Preparatory Course contained 18 online learning modules covering basic concepts in anatomy, auscultation, echocardiography, catheterisation, cardiovascular intensive care, electrophysiology, pulmonary hypertension, heart failure, and cardiac surgery. Each online learning module included an instructional video with pre- and post-video tests. Participants completed pre- and post-Online Preparatory Course knowledge-based exams and surveys. Pre- and post-Online Preparatory Course survey and knowledge-based examination results were compared via Wilcoxon sign and paired t-tests. **Results:** 151 incoming paediatric cardiology fellows from programmes across the USA participated in the 3 months prior to starting fellowship training between 2017 and 2019. There was significant improvement between pre- and post-video test scores for all 18 online learning modules. There was also significant improvement between pre- and post-Online Preparatory Course exam scores (PRE $43.6 \pm 11\%$ versus POST $60.3 \pm 10\%$, $p < 0.001$). Comparing pre- and post-Online Preparatory Course surveys, there was a statistically significant improvement in the participants' comfort level in 35 of 36 (97%) assessment areas. Nearly all participants (98%) agreed or strongly agreed that the Online Preparatory Course was a valuable learning experience and helped alleviate some anxieties (77% agreed or strongly agreed) related to starting fellowship. **Conclusion:** An Online Preparatory Course prior to starting fellowship can provide a foundation of knowledge, decrease anxiety, and serve as an effective educational springboard for paediatric cardiology fellows.

The transition from paediatric residency to cardiology fellowship can be challenging as fellows are required to rapidly develop new knowledge and procedural skills within a short period of time. To ease this transition to fellowship, we developed a multi-day comprehensive paediatric cardiology boot camp aimed at creating a foundation of knowledge and skills for future paediatric cardiology fellows. Our single-centre pilot study in 2015 demonstrated that this boot camp experience improved knowledge and reduced anxieties prior to the start of formal paediatric cardiology fellowship training.¹ Our subsequent study revealed that boot camp participants demonstrated a significant improvement in basic cardiology knowledge with excellent moderate-term retention and began fellowship with a larger fund of knowledge than those fellows who did not attend our boot camp.² Our boot camp has now become a nationally recognised annual programme for future paediatric cardiology fellows from programmes throughout the United States and Canada.

Unfortunately, not all trainees will have the ability or access to attend a paediatric cardiology boot camp prior to starting fellowship. In contemporary medical education, web-based learning has gained prominence as an effective teaching method not only for knowledge content but also skills acquisition.^{3–7} Studies have shown that web-based learning can be an effective method to acquire skills such as electrocardiogram interpretation, minimally invasive surgery techniques, and ultrasound-guided access techniques.^{3,4,6,7} An online web-based educational course is an ideal platform to disseminate basic paediatric cardiology knowledge and skills that can be easily accessible to all incoming paediatric cardiology fellows prior to starting their training.

We sought to determine whether an online preparatory course can effectively introduce important core principles in a wide variety of paediatric cardiology subspecialty areas, giving fellows a springboard from which to start fellowship. We also sought to determine whether an online preparatory course improves fellows' comfort and decreases anxiety surrounding the acquisition of basic knowledge and technical skills as they enter their paediatric cardiology training.

Methods

The online preparatory course consisted of 18 online learning modules on a Digital Medic electronic platform. The 18 online learning modules covered core cardiology concepts in anatomy, auscultation, echocardiography, catheterisation, cardiovascular intensive care, electrophysiology, pulmonary hypertension, heart failure, and cardiac surgery (Table 1). Each online learning module included an instructional video averaging 10 minutes in length (range 8–13 minutes) with pre- and post-video tests. The instructional video for each online learning module was tailored for the designated topics listed in Table 1 and utilised a variety of media. This included narrated PowerPoint slides with images and animations, narrated movies, audio clips, video simulations, review of live pathology specimen dissections, and videos of intraoperative cardiac surgery as appropriate. The instructional videos for online learning modules 8 and 16 with practice components took learners through haemodynamic calculations and ECG interpretations in a step-by-step fashion. The goal of each video was to be as interactive as possible with the learner.

The online preparatory course was offered to any paediatric resident who planned to initiate a paediatric cardiology fellowship in the following academic year (2017–2019). Participants were recruited by electronic advertisement for the online preparatory course and through individual paediatric cardiology fellowship programme directors. Participation was completely voluntary. Participants were given access to the prep course starting approximately 3 months prior to the start of fellowship until the course ended at the start of fellowship training in July of each year. They were allowed to complete the online preparatory course at their own pace over the 3 months duration. Knowledge-based exams and surveys were given pre- and post-course, utilising the same questions as the in-person paediatric cardiology boot camp.¹ Participants that did not complete the post-prep course knowledge-based exam were excluded from analysis. The study was approved by the Stanford University Institutional Review Board.

Metrics

Each participant was asked to complete an exam consisting of 28 multiple-choice questions to assess their baseline knowledge of core paediatric cardiology concepts prior to starting the online preparatory course. The examination was created and designed by the faculty, and participants were blinded to the scores, results, and answers after the pre-test was administered. In addition, each of the 18 online learning modules had short pre- and post-video tests consisting of three questions each. Participants were required to complete a pre-course survey to assess their self-reported baseline comfort level prior to the start of the online preparatory course. The survey included questions regarding their comfort level and self-assessment of knowledge in various areas of paediatric cardiology. The survey questions were ranked on a five-level standard Likert scale (ranging from Strongly Disagree to Strongly Agree).

After completing the online preparatory course, participants were required to complete the same exam consisting of 28 multiple-choice questions to reassess their knowledge of core paediatric cardiology concepts. They were also asked to complete a post-course survey to reassess their self-reported comfort level and knowledge in various areas of paediatric cardiology using the same questions as the pre-course survey. After completion of the online preparatory course, a course evaluation survey was also sent to each participant with answers ranked on a five-level standard Likert scale (ranging from Strongly Disagree to Strongly Agree).

Data presentation and statistical analysis

Statistical analysis was performed using Stata (version 12, Stata Corp. LP, College Station, TX). Pre- and post-online learning module tests as well as pre- and post-preparatory course exams were compared via paired t-tests. Results are reported as mean $\pm$ SD. Pre- and post-course survey results are reported as mean with standard error of the mean and were compared via the Wilcoxon sign test. All two-sided p values <0.05 were considered statistically significant.

Results

Participants

There were 225 trainees that initially enrolled in the preparatory course. A total of 151 (67%) trainees completed all 18 modules as well as the pre- and post-course exams and were therefore included in the analysis. Of the 151 participants included for analysis, 141 (93%) completed the pre- and post-course surveys. The participants were all trainees who would be initiating a paediatric cardiology fellowship in the following July after the course. Most of the participants included for analysis (71.5%) were paediatric or combined internal medicine/paediatric residents with the rest being a combination of paediatric hospitalists, paediatric chief residents, general paediatricians, and intensive care or anaesthesia fellows.

Pre- and post-online learning module test scores

All participants showed a significant improvement in their post-video test scores compared to their pre-video test scores for each of the 18 online learning modules. The pre-video and post-video test scores for each of the 18 online learning modules are shown in Table 1.

Pre- and post-preparatory course exam scores

All participants showed an improvement in their post-course exam scores compared to their pre-course scores. The mean pre-course exam score for the cohort was $43.6 \pm 11\%$. Significant improvement was seen in the post-course exam scores with a mean of $60.3 \pm 10\%$ ($p < 0.001$, Table 1).

Pre-prep course versus post-prep course survey results comparison

A detailed graphical depiction of the pre- and post-preparatory course survey results is demonstrated in Figure 1. Of the 36 survey questions assessing their self-reported comfort level with basic paediatric cardiology knowledge and skills, there was a statistically significant improvement in the participants' comfort level in 35 of 36 (97%) areas of self-assessment. The one area that fellows did not

Table 1. Mean scores on pre-video and post-video tests for each Online Learning Module (OLM) as well as pre- and post-preparatory course exam scores. The pre- and post-video scores are displayed as mean $\pm$ standard deviation. There was a significant improvement in post-test scores compared to pre-test scores for each of the 18 online modules as well as the overall Course Exam.

	Pre-video test score	Post-video test score	p- value
OLM 1: Normal Cardiac Anatomy	47 $\pm$ 30%	77 $\pm$ 25%	<0.001
OLM 2: Heart Sounds	48 $\pm$ 23%	73 $\pm$ 25%	<0.001
OLM 3: Murmurs	87 $\pm$ 19%	97 $\pm$ 11%	<0.001
OLM 4: Basics of Echocardiography	77 $\pm$ 27%	83 $\pm$ 30%	0.023
OLM 5: Normal Echocardiography Views	40 $\pm$ 21%	57 $\pm$ 20%	<0.001
OLM 6: Cardiac Catheterization Hemodynamics Part 1	38 $\pm$ 26%	77 $\pm$ 26%	<0.001
OLM 7: Cardiac Catheterization Hemodynamics Part 2	36 $\pm$ 29%	81 $\pm$ 24%	<0.001
OLM 8: Cardiac Catheterization Hemodynamics Practice Calculations	62 $\pm$ 32%	84 $\pm$ 28%	<0.001
OLM 9: Emergencies in the CVICU	29 $\pm$ 30%	97 $\pm$ 10%	<0.001
OLM 10: CVICU Rhythm Management	50 $\pm$ 28%	85 $\pm$ 32%	<0.001
OLM 11: Cardiopulmonary Bypass	35 $\pm$ 32%	87 $\pm$ 24%	<0.001
OLM 12: Introduction to Ventricular Assist Devices	44 $\pm$ 30%	91 $\pm$ 18%	<0.001
OLM 13: VAD Complications	46 $\pm$ 18%	61 $\pm$ 15%	<0.001
OLM 14: Pediatric Pulmonary Hypertension	55 $\pm$ 29%	84 $\pm$ 18%	<0.001
OLM 15: Introduction to ECG Part 1: Basic Principles	15 $\pm$ 26%	59 $\pm$ 28%	<0.001
OLM 16: Introduction to ECG Part 2: How to Read an ECG	51 $\pm$ 26%	59 $\pm$ 28%	0.006
OLM 17: Introduction to ECG Part 3: Practice ECG Reading	48 $\pm$ 29%	60 $\pm$ 33%	<0.001
OLM 18: Introduction to Pacemakers and Implantable Cardioverter Defibrillators	21 $\pm$ 24%	60 $\pm$ 29%	<0.001
	Pre- course test score	Post- course test score	p- value
Preparatory Course Exam	44 $\pm$ 0.11%	60 $\pm$ 0.10%	<0.001

achieve a statistically significant improvement in their comfort level after the online preparatory course was distinguishing systolic from diastolic murmurs.

Course evaluation results

When evaluating the course, almost all of the participants (98%) strongly agreed or agreed that the online preparatory course was a valuable learning experience. The majority of participants (77%) strongly agreed or agreed that the online preparatory course

helped alleviate some anxieties about starting fellowship. A graphical description of the participants' post-preparatory course evaluation is demonstrated in Figure 2.

Excluded trainees that did not complete the course

There were 74 trainees that were excluded from the analysis because they did not complete the entire course. Thirty-four (46%) of them enrolled but did not start any part of the course. Of the 40 participants that started the course, 17 (41%) completed less than half of the course with an average number of 10.8 ± 5.5 online learning modules completed. When comparing the excluded trainees who did not complete the course to the included trainees who completed the course, there was no difference in the average pre-video scores ($46.9 \pm 12.6\%$ versus $46 \pm 9.2\%$, $p = 0.6$) or average post-video scores ($77.9 \pm 11.7\%$ versus $76.9 \pm 9.1\%$, $p = 0.57$) for all completed online learning modules. In addition, there was no difference in the average Pre-Prep Course score when comparing the excluded trainees who did not complete the course to the included trainees who completed the course ($45.9 \pm 23.2\%$ versus $43.6 \pm 11.3\%$, $p = 0.38$). The majority of the excluded trainees were paediatric or combined internal medicine/paediatric residents (71.6%) which was similar to the make-up of the included trainees who completed the course (71.5%, $p = 0.39$).

Discussion

In this study, we have demonstrated that an online preparatory course can effectively improve basic knowledge of core principles and technical skills to provide a springboard for fellows at the start of a paediatric cardiology fellowship programme. In addition, the online preparatory course improved self-confidence and reduced anxiety for the majority of the trainees during this already difficult transition period in their training.

The goals of most boot camps are to teach information in a given discipline, introduce basic skills and techniques that will be learned and mastered during residency or fellowship training, as well as provide a foundation to start training with more confidence and decrease anxiety.^{1,2,8-11} These boot camp experiences have traditionally included simulation and technical skills workshops.^{1,2,9,10,12,13} However, such experiences can be financially demanding and time intensive as they require specialised simulation equipment, participant travel, and significant faculty involvement for planning and executing a meaningful boot camp experience. We have previously published our experience with our Stanford Pediatric Cardiology Fellowship Boot Camp demonstrating the positive educational benefits.^{1,2} Unfortunately, we are only able to offer the Stanford Pediatric Cardiology Fellowship Boot Camp experience to 40 participants annually which is less than 25% of the total number of paediatric cardiology fellows that start fellowship each year. Ideally, boot camps would be readily accessible and attended by all incoming trainees.

With advancement in technology and increased internet accessibility, online courses have gained prominence as an effective training method in medical education and have been utilised for nurses, medical students, residents, and faculty. Web-based learning has been effective for increasing knowledge as well as teaching technical skills.^{4,6,12-15} E-learning curricula in orthopaedic surgery, otolaryngology, and general surgery training have been shown in multiple studies to not only improve knowledge on exams but also improve scores on Objective Structured Clinical Exams and other evaluations of technical skills.^{12,14,15}

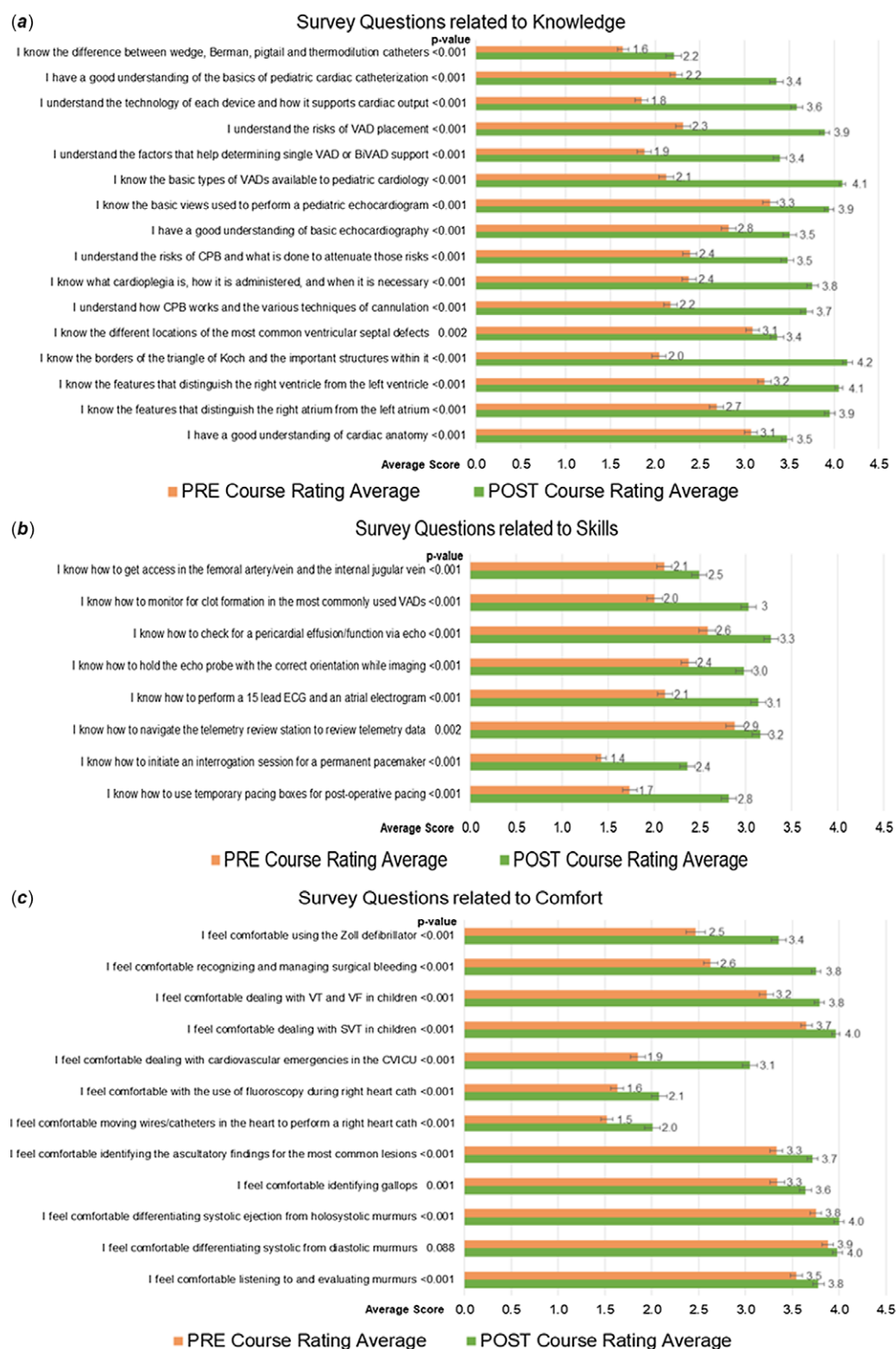


Figure 1. Pre- and post-prep course survey results. The figure demonstrates a comparison of the pre-course survey (orange) and post-course survey (green) responses. Data are presented as mean with standard error of the mean, and comparisons were made statistically via Wilcoxon sign test. The figures demonstrate responses to questions related to (a) knowledge, (b) skills, and (c) comfort.

An online platform provides the ability to increase access to education for all trainees worldwide. In addition, web-based learning can accommodate a broad variety of learning styles and allow for self-paced learning. While online education has been used throughout various medical fields for ongoing education, there are currently no reports of the effectiveness of an online preparatory course to help transition trainees from residency to fellowship.

In our study, we presented 18 online learning modules covering a variety of different subspecialty topics within paediatric cardiology. While all participants showed an improvement in the post-video test scores for each online learning module, it is interesting to note the topics that appeared to have the greatest increase from mean pre-video to mean post-video test scores. The post-video test scores with the greatest increase from pre- to post-video test

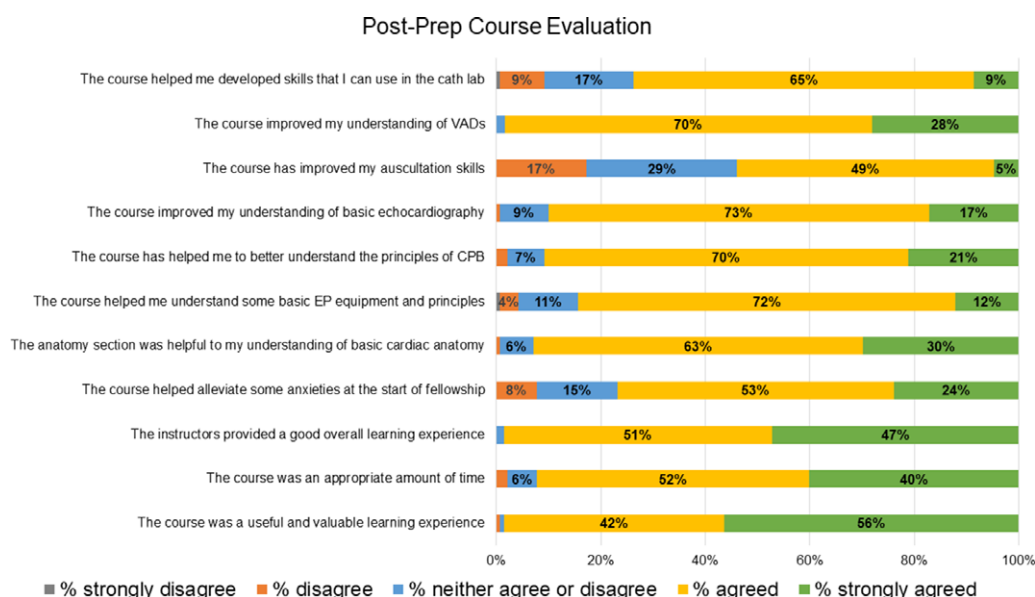


Figure 2. Post-prep course evaluation survey results.

scores included Cardiac Catheterization Hemodynamics part 2 (online learning module 7), Emergencies in the CVICU (online learning module 9), Cardiopulmonary Bypass (online learning module 11), Introduction to Ventricular Assist Devices (online learning module 12), Introduction to ECG Part 1: Basic Principles (online learning module 15), and Introduction to Pacemakers and Implantable Cardioverter Defibrillators (online learning module 18). This finding may be a reflection of relatively decreased exposure to these specific topics in general paediatric residency training compared to the other topics such as heart sounds and murmurs which are more likely to be emphasised during residency training. This highlights the challenges of paediatric cardiology fellowship where trainees are required to rapidly acquire knowledge and procedural skills in areas with little exposure during paediatric residency training. This further supports the benefits of an online preparatory course to provide a knowledge foundation even prior to starting fellowship.

Our study is the first to demonstrate that an online video-based Pediatric Cardiology Fellowship Online Preparatory Course can be a valuable educational tool to help incoming paediatric cardiology trainees transition from residency to fellowship. These results demonstrate that an online preparatory course can increase basic paediatric cardiology knowledge and teach basic techniques and procedural skills to launch fellows in their clinical fellowship training with more confidence and less anxiety.

Limitations

There are several limitations to this study. The pre- and post-course exam results demonstrate short-term retention and improvement in knowledge, but do not assess long-term effects of the online preparatory course. Whether the knowledge and skills learned during this training translate into long-term knowledge and improved performance is yet unknown. The participants were also blinded to the results of the pre- and post-video tests for each online learning module as well as the pre- and post-course exams, but it is also possible that the act of taking the test a second time could theoretically bias the post-test scores. In addition, participants were given 3 months to complete the entire online

preparatory course at their own pace. There are no tracking data to assess the amount of time elapsed within each module, between modules, and between modules and the post-course exam. Therefore, there may be some retention bias depending on the duration over which each participant completed the entire course. It is also notable that 33% of enrolled trainees did not complete the entire course and were excluded from the main analysis. Almost half of those excluded did not even start any part of the course. Interestingly, when comparing the excluded trainees who did not complete the course to the included trainees who completed the course, there was no difference in pre-course scores, completed pre-video scores, completed post-video scores, or types of trainees in the group. Given the similar performance for the completed work, the most likely reason for trainees not completing the course is a matter of time commitment. The majority of trainees were residents, and the course was made available during their final 3 months of residency prior to starting fellowship, which is often a busy time. An online course requires the learner to make the time to commit to taking the course, as with any online educational tools. The exact reasons for not completing the course, however, are not known from the data collected in this current study and could potentially contribute to bias effects on the results. Future studies will investigate any barriers preventing trainees from completing the course to allow for as many trainees as possible to benefit from this online educational experience. Finally, while the participants report a greater comfort with technical aspects of cardiology after the online preparatory course, it still remains to be seen whether this also translates into a procedural competency or significant improvement in technical skills. In addition, while there was a statistically significant improvement in participants' self-reported comfort level in almost all of the surveyed areas, the magnitude of meaningful clinical improvement in comfort may be challenging to assess.

Conclusions

A paediatric cardiology online preparatory course prior to the start of paediatric cardiology fellowship can provide a strong foundation of knowledge and skills to serve as an educational springboard for

paediatric cardiology fellows to improve confidence and reduce anxiety. Further evaluation of the long-term effects on knowledge retention, procedural competency, and clinical performance is warranted.

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Conflicts of interest. None.

Ethical standards. Not applicable

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