BMJ Open

An Adaptive International Cardiology Curriculum Accessible by Remote Distance Learning: The Haiti Experience (iCARDs-Haiti)

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-048690
Article Type:	Original research
Date Submitted by the Author:	04-Jan-2021
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Keywords:	MEDICAL EDUCATION & TRAINING, CARDIOLOGY, PUBLIC HEALTH

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An Adaptive International Cardiology Curriculum Accessible by Remote Distance Learning: The Haiti Experience (ICARDs-Haiti)

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Word Count: 3638

Acknowledgements: Special thank you to the internal medicine residents at Hôpital Universitaire de Mirebalais, Dr. Jean-Pierre Brisma, Zanmi Lasante, Dr. Merly Robert, Dr. Gene Kwan, UPenn cardiology fellows, Dr. Garly Saint-Croix, Dr. Michel Ibrahim, Dr. Benedicte LeFevre, Dr. Anne Christine Buteau, Dr. Krystal Hill, Dr. Rodcnel Sainvilien, Dr. Frank Silvestry, Dr. Paul Mather, Dr. Victor Ferrari, Dr. Mahesh Vidula, Dr. Sri Adusumalli, Denice Susini, Jennifer Cronin, and funding from the Penn Cardiovascular Disease Fellowship Innovation Fund

Author contributions:
N.H., V.S.J., conceived and planned the study. N.H., V.S.J., F.V.V., C.D., D.L., and M.A., carried out the study. N.H., V.S.J., performed data collection. A.T., N.H., V.S.J., J.B., M.A., J.A.S., performed data analysis and interpretation. N.H., J.B., V.S.J., drafted the manuscript. M.A., J.S.A., A.E., performed critical revision of the article. N.H., V.S.J., J.B., A.E., F.V.V., C.D., D.L., A.T., J.A.S., and M.A., approved the article to be published.

Funding: The Penn Cardiovascular Disease Fellowship Innovation fund provided funding for statistical support.
Disclosures: There are no relationships with industry to report. All authors have nothing to disclose

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Abstract:

Background: Cardiovascular disease (CVD) remains a leading cause of morbidity and mortality worldwide, conferring a disparate burden on low and middle-income countries (LMICs). Haiti represents a resource-constrained setting, limited by a paucity of resources and trained cardiovascular professionals equipped to address the increasing burden of CVD.

Objective: Here we describe the creation of a comprehensive cardiology curriculum delivered through a virtual classroom. The curriculum was created to give local providers in low resource settings such as Haiti the skills necessary to provide the best possible care with locally available resources.

Methods: Over one academic year (May 2019-2020), ICARDs-Haiti consisted of biweekly live-streamed, synchronous didactic lectures, seminars and case presentations broadcast to 16 internal medicine (IM) residents at Hôpital Universitaire de Mirebalais (HUM), 1 of only 4 IM training programs in Haiti. The virtual classroom was created using commercially available video conferencing and data-sharing platforms. Pre- and post-lecture surveys and an end of the year survey were administered to assess the impact of the curriculum.

Results: Analysis of participant performance revealed that the majority of the curriculum was associated with moderate to large improvement as seen in effect sizes. Based on the end of the year evaluation, participants reported that the curriculum was educational and relevant to medical practice in Haiti. Additionally, it helped to maintain educational opportunities for trainees during the COVID-19 pandemic.

Conclusion: This medical education pilot study demonstrates the feasibility of augmenting cardiology education in LMICs by creating a virtual curriculum made possible by local partnerships, internet access, and technology.

Article Summary:

Strengths:

- To our knowledge, this study is the first to describe and present data in support of the utilization of an international cardiology curriculum and virtual cardiology education program in low resource settings such as Haiti to supplement onsite global health educational endeavors.
- This study demonstrated that the majority of the curriculum was associated with moderate to large improvement in participant performace as seen in effect sizes.
- This study demonstrated that the curriculum was relevant to clinical practice in Haiti and enabled education to continue despite travel restrictions and social distancing imposed due to the COVID-19 pandemic. Additionally, this study highlights the grassroots nature of the ICARDs-Haiti virtual curriculum and enables young researchers early in their careers and physicians from LMICs such as Haiti to engage scholarship.

Limitations of the study:

- One limitation of the study is the small sample size.
- Given the use of immediate post lecture assessments, the impact on long-term knowledge retention is unclear.

Keywords: *Haiti, international cardiology curriculum, global health, distance learning*

Introduction:

While this decade has seen an overall decline in premature morbidity and mortality from communicable diseases, substantial progress has been offset by a steady rise in non-communicable diseases (NCDs). Of these, cardiovascular disease (CVD) has become the single most critical source of NCD deaths worldwide.[1] In 2012, the World Health Organization (WHO) estimated that 17.6 million people died of CVD globally, with a disproportionate burden of deaths falling on low and middle-income countries (LMICs).[2] With over 80% of cardiovascular deaths occurring in LMICs, proportionally, this disparity accounts for an estimated 31.3% of global mortality.[3] The alarming increase in the global burden of CVD and associated risk factors provide a compelling argument in support of prioritizing urgent yet carefully planned efforts to prevent and control this global epidemic, especially in LMICs. It is unlikely, however, that low-income countries, such as Haiti, can overcome this tremendous burden without expanding their skilled human resources, healthcare infrastructure and medical education.

In Haiti, CVD accounts for 29% of all deaths.[4] The incidence of peripartum cardiomyopathy is one of the highest in the world at a rate of 1 in every 300 deliveries.[5] Haiti also has a relatively high prevalence of rheumatic heart disease (RHD) at 5% in rural settings and a high prevalence of hypertensive cardiomyopathy and stroke.[6,7] Untreated hypertension and diabetes are most commonly implicated as the cause of the aforementioned conditions. There is also a lack of cardiovascular healthcare infrastructure in Haiti. Although most hospitals have access to EKG machines, there are no catheterization laboratories in the country. Acute coronary syndromes (ACS) are typically managed medically. There is limited access to cardiac surgery through non-governmental organizations (NGOs). Additionally, due to a lack of trained professionals, few hospitals routinely use echocardiography despite its high diagnostic value.

Currently, there are only 25 physicians per 100,000 people, 6.5 healthcare providers per 10,000 people (including nurses) and an estimated 16 cardiologists countrywide for a population of over 11 million people.[8,7,9] The ability to obtain advanced medical training after medical school is limited. Upon graduating from medical school, most physicians immediately start working as general practitioners (GPs) with about 5% of medical school graduates enrolling in 1 of 4 competitive internal medicine (IM) residency programs in the country.[10,11] There are no formal cardiology training programs in Haiti. The 16 cardiologists who currently work in Haiti received their training outside of Haiti given the absence of formal postgraduate training programs in cardiovascular disease. Many obtained formal cardiology fellowship training in countries such as France, Cuba and the United States of America (USA). Given the lack of training opportunities and cardiologists in the context of high CVD burden, it is apparent that there is a need for additional cardiovascular education support for healthcare providers both in and out of training programs.

Hôpital Universitaire de Mirebalais (HUM) is 1 of only 4 IM residency programs in Haiti, training an estimated 20-25% of all IM residents in the country.[11] HUM is one of the largest teaching hospitals and one of the only to receive accreditation from the Accreditation Council for Graduate Medical Education International (ACGME-I). [12] HUM has an integrated public and private structure with a robust partnership with Haiti's Ministry of Health. Its structure enables it to be both affordable and accessible to the general

public. HUM also has access to imaging modalities such as computed tomography (CT) and ultrasound making echocardiography possible. Due to the affordability and high reputability of HUM, it serves as a large referral center. Patients travel long distances to seek treatment for some of the most advanced diseases and severe pathology. This holds true for cardiovascular patients with nearly 40% of all admissions to the internal medicine ward being for heart failure and 60% of those heart failure admissions being women.[6] Despite the high prevalence of CVD among hospitalized patients at HUM, however, access to cardiologists is limited. Thus, the IM residents are left to care for these patients without access to optimal cardiovascular education and support.

In an attempt to address the needs at HUM, one of the largest teaching hospitals which serves a sizable catchment area, we developed a pilot educational program through the creation of an international virtual classroom to deliver an adaptive cardiovascular curriculum to IM residents at HUM. Initially developed and executed before the COVID-19 pandemic began, the purpose of ICARDs-Haiti has evolved. The value and goals of the curriculum are now two-fold: to provide pertinent educational material and also to maintain educational activities during the ongoing COVID-19 pandemic in Haiti. Here, we describe a proof-of-concept and first attempt at bridging the cardiovascular education and training divide in a resource-limited setting through the execution of a virtual classroom utilizing live-streamed, lectures and an interactive discussion format.

Methods:

In May 2019, ICARDs-Haiti was created by a chief resident at Hôpital Universitaire de Mirebalais (who is now a cardiology trainee in France) and a University of Pennsylvania (UPenn) Cardiology fellow under the auspices of the educational leadership from their respective institutions. Thereafter, a formal international collaboration between HUM physicians and UPenn cardiologists was forged with the objective to create a dynamic, adaptive and comprehensive curriculum that included locally relevant and useful educational cardiology content. An IRB exemption was obtained from the Zanmi Lasante/HUM IRB committee.

Prior to the initiation of ICARDs-Haiti, the cardiology curriculum at HUM was undergoing significant restructuring due to the lack of a full-time cardiovascular specialist. The HUM IM faculty created a list of pertinent cardiovascular topics. They planned for oral presentations by residents and a weekly academic discussion with a local cardiologist. Despite the aforementioned aspirations, in practice, the amount of time that local cardiovascular specialists were able to commit to education at HUM was limited. Additionally, due to travel restrictions that were imposed due to political instability (and later the COVID-19 pandemic) visiting cardiologists from the USA and Europe were unable to visit to support trainees and faculty at HUM. The consequence of these limitations was a lack of routine, consistent and comprehensive cardiovascular education despite the high CVD burden among HUM patients. Due to the need for improved and continual cardiovascular education, HUM chief residents and a HUM-affiliated, local cardiologist sought assistance in creating a more consistent and comprehensive cardiology curriculum for HUM's trainees by soliciting assistance from colleagues abroad who had spent significant time in Haiti. A global network of medical educators was subsequently created to address this need. Through international collaboration, a revised list of pertinent cardiology topics and respective learning objectives relevant to medical practice in Haiti was created. The American College of Cardiology (ACC) core competency recommendations for cardiology trainees were also used as a guide. Volunteer lecturers consisted of cardiology fellows, attendings and internists from UPenn, Boston University, Mount Sinai medical center in Miami, New York University (NYU), SUNY Downstate and Centre Hospitalier d'Antibes Juan-les-Pins (Provence Alpes Côtes d'Azur, France). Many of the lecturers had personal ties to Haiti and were also multilingual. Lectures were given in either English, French, Haitian Creole or a mixture of these

languages. The assessed curricular content was created and delivered by 8 lecturers 50% of whom were multilingual. The vast majority of IM residents at HUM are fluent in English, French and Haitian Creole, although English comprehension skills are variable. The curriculum was implemented using the ADDIE training model (Analysis, Design, Development, Implementation, Evaluation), an instructional design methodology.[13] It is currently being used as a guide for the implementation and adaptation of this curriculum based on written and verbal feedback from the IM residents.

Lectures were executed biweekly via video conference platforms and each lecture was preceded and followed by anonymous, unmatched pre- and post-knowledge assessments. The assessments were delivered via the Qualtrics program and distributed via a commercially available, internet-based mobile phone communication application. Lecture reading materials were distributed via SLACK (Searchable Log of All Conversation and Knowledge), an online communication platform. The cardiovascular topics and learning objectives for the curriculum were determined by a leadership council which consisted of cardiovascular fellows and faculty at UPenn as well as the IM program director and the chief residents at HUM and a local Haitian cardiologist. The content for each lecture was created by volunteer lecturers from the aforementioned institutions and was reviewed by the leadership council. In total, 20 live-streamed, biweekly synchronous sessions, which included active audience participation, were delivered. The live-streamed lectures were supplemented with case presentations and seminars. The cardiology topics covered in the curriculum included stenotic valvular lesions, regurgitant valvular lesions, heart failure (HF), peripartum cardiomyopathy (PPCM), cardiogenic shock, pharmacology of HF medications (therapeutics, inotropes and vasodilators), congenital heart disease (CHD) specifically atrial septal defects, rheumatic heart disease (RHD), preoperative risk assessment, peripheral arterial disease (PAD), echocardiography basics, COVID-19, syncope, hypertension and interactive EKG conferences. For most of the aforementioned topics, the following content was provided: physiology, pathophysiology, clinical presentation, physical exam findings, medical management and indications for interventional procedures and surgery. For pre-operative risk assessment, the risk stratification of various surgeries and patients, preoperative work-up and perioperative medication management were discussed. For echocardiography, the acquisition and interpretation of basic echocardiography views was reviewed. Two new categories were created for data analysis, surgical appropriateness and critical care management. Surgical appropriateness consisted of content that covered preoperative risk assessment and indications for interventional procedures or surgery for CHD and valvular disease. Critical care management consisted of content that covered the differentiation and management of shock based on physical exam and hemodynamic profiles. Acute respiratory distress syndrome (ARDS) was also discussed in the specific context of the COVID-19 pandemic.

Between May 2019 and May 2020, there were 16 IM residents at HUM of whom 20% were women and 80% were men. There were 6 first year residents, 5 second year residents and 5 third year residents. The ages of the IM residents ranged from 25-30 years old. The ICARDs curriculum was integrated into the trainees' pre-existing didactic schedule. Thus, all 16 residents participated in this 1-year research study. Sessions were held on Monday evenings for one hour. Surveys included subjective confidence rating assessments typically with 5 answer choices that most commonly ranged from strongly disagree to strongly agree. Objective assessments took the form of multiple-choice questions with correct and incorrect answers (appendix 1).

Patient and Public Involvement: Patients or the public were not involved in the design, or conduct, or reporting, or dissemination of this research.

Statistical analysis:
Statistical analysis was performed using SAS software. The Wilcoxon Mann-Whitney U-test was used for data analysis due to the non-parametric nature of the data and the small sample size. Cohen's (r) was used to estimate effect sizes. Effect sizes ranging from 0.1 to <0.3 were interpreted as small, effect sizes ranging from 0.3 to <0.5 were interpreted as moderate, and effect sizes of 0.5 and greater were interpreted as large.[14]

Results:
Analysis of 56 items (see appendix) revealed that 32% of the assessed curricular content was associated with a small effect size, 39% was associated with a moderate effect size and 29% was associated with a large effect size. The small effect size category was further subdivided into a small effect size due to the Ceiling Effect and a small effect size without the Ceiling Effect. We defined the Ceiling Effect as subjective or objective assessments associated with a small effect size <0.3 for which the post-assessments had perfect scores (the ceiling). The percentage of the curriculum with a small effect size with and without the Ceiling Effect was 12% and 20% respectively (Figure 1). When the 56 items were analyzed based on topic category, we found that the majority of the effect sizes for surgical appropriateness, critical care management, PAD, valvular disease and CHD were moderate to large suggesting that these topics had more of an impact (Figure 2). In contrast, HF, echocardiography, and pharmacology had a larger proportion of small effect sizes implying that there was no meaningful difference between the pre- and post-assessments (Figure 2).

A notable proportion of the small effect sizes were due to the Ceiling Effect with high pre-assessment scores and post-assessment scores of 100% (Table 1). Additionally, Figure 3 shows that topics taught by monolingual English speakers were associated with a higher proportion of small effect sizes without the Ceiling Effect (24%) when compared to lectures provided by multilingual lecturers (14%). Four objective assessments; comprehension of the continuity equation, appropriate dosing of dopamine for cardiogenic shock, identifying a hemodynamically significant Qp:Qs ratio (shunt fraction) and correctly identifying all guideline directed medical therapy (GDMT) for HF, were associated with small negative effect sizes, due to a slightly higher proportion of students answering the objective questions correctly prior to the intervention. Notably, these topics were taught by monolingual English Speakers (Table 1).

All participants completed an end of the year survey. When asked whether the material covered by the curriculum was relevant to medical practice in Haiti, 56.3% of participants agreed and 37.5% strongly agreed. When asked about the commitment of the course directors, 12.5% of participants reported the commitment as good and 87.5% as very good to excellent. In the context of clearly delineated learning objectives, all participants reported learning what they expected from the curriculum with 46% reporting that the curriculum exceeded their learning expectations. For the overall evaluation of the course, all participants reported that the course was good to excellent. When asked if they would like to incorporate recorded lectures into the curriculum, 25% of participants reported that they preferred only live lectures, 75% preferred a mix of live and pre-recorded lectures and 0% preferred only pre-recorded lectures.

When asked how the curriculum could be improved, participants recommended streamlining the lectures, increasing the number of practice questions, incorporating French and Haitian Creole verbal or written translation into the lectures and implementing a hands-on echocardiography experience. Participants identified a number of strengths which included but were not limited to the diversity of lecturers, incorporation of French and Haitian Creole into some of the lectures, the relevance of the content to

medical practice in Haiti, the amount of material learned and the pre- and post-lecture questions as pertinent learning aids to reinforce retention of the information presented in the lectures.

Discussion:

In an attempt to address the deficiency of formal cardiovascular education and routine access to cardiologists in Haiti, we created a virtual, collaborative, international cardiology curriculum for IM trainees at HUM, where nearly 40% of all admissions to the medical ward are due to CVD.[6] The aforementioned results suggest that the curriculum has been impactful. Analysis demonstrated that 68% of the assessed curriculum had a moderate to large effect size indicating a noteworthy educational impact based on pre- and post-lecture assessments. When small effect sizes due to the Ceiling Effect are included, 80% of the curriculum demonstrates a positive trend in knowledge acquisition post-intervention.

The topics associated with moderate to large effect sizes included surgical appropriateness, critical care management, PAD, CHD and valvular heart disease. After receiving the curriculum, trainees felt more confident in their ability to identify indications for interventional procedures and surgical intervention for valvular disease and CHD. Trainees were also more confident in knowing when to appropriately refer patients to cardiovascular specialists for corrective interventions. Additionally, trainees demonstrated an improvement in the objective assessments of preoperative risk, medical management of valvular disease and critical care management. An improvement in the assessment scores of the aforementioned topics is important given the high prevalence of RHD and severe HF among patients admitted to HUM. Based on a study by Kwan et al. from 2016, 37% of all HUM admissions were for HF and more than 60% of HF patients were women.[6] Of those women with cardiomyopathy, 50% were diagnosed with PPCM. [6] Five percent of cardiovascular admissions were due to RHD with notable valvular disease identified by echocardiography.[6] Notably, although access to cardiac surgery is restricted, organizations such as the Haiti Cardiac Alliance (HCA) work to facilitate surgical referrals and long-term follow up for cardiac surgery patients in Haiti.[15] Thus, educating GPs and internists on timely referral of cardiovascular patients to specialists and entities equipped to provide specialized care, as well as corrective interventions, can improve cardiovascular outcomes for patients with severe CVD in Haiti.

The topics associated with a large proportion of the small effect sizes are shown in Table 1. Many of the small effect sizes were explained by trainee's pre-existing medical knowledge and comfort with those topics. One reason that trainees may have scored highly on a number of the pre-assessments could be from prior exposure to these topics, before ICARDs-Haiti curriculum implementation. Additionally, trainees were not separated by their training year. Senior residents were likely to be more familiar with some of these topics than junior residents were, thus creating smaller effect sizes than if trainees had been separated by their training year.

Four topics (shunt fraction, continuity equation comprehension, HF guideline-directed medical therapy (GDMT) and Dopamine dosing) were associated with small negative effect sizes. All 4 of these assessments were objective and were taught only in English without French or Haitian Creole translation. Thus, the lack of a positive and moderate to large effect size for these topics is likely multifactorial and causality may include a lack of content clarity, topic complexity and language comprehension. A larger proportion of topics taught by multilingual lecturers with personal ties to Haiti, were associated with moderate to large effect sizes. This highlights the importance of not only language, but also cultural contextualization for learning. These findings represent a real-world application of a curriculum that helped to fill an educational void that hopefully also enhanced peer-to-peer education. Furthermore, all participants completed the end of the year general assessment for which the overall rating of the

curriculum was good to excellent. The residents also reported that the topics covered in the curriculum were highly relevant to current medical practice in Haiti given the focus on HF (including peripartum cardiomyopathy), hypertension and RHD.

Looking ahead, we plan to modify the ICARDs curriculum to better address the educational needs in this region. We will provide written or verbal French or Haitian Creole translation for all future lectures. For the topics associated with small effect sizes without the Ceiling Effect, we will reevaluate and restructure these lectures for improved clarity, in joint consultation with our Haitian collaborators. For the topics associated with small effect sizes with the Ceiling Effect (implying that the trainees were already familiar with the topics), we will refocus our educational efforts on other higher yield topics. Learning objectives for various topics will be stratified by training year. To improve on the objective assessment results, we will incorporate more homework assignments which will then be reviewed in smaller, interactive seminar sessions, that support comprehension of complex topics. To diversify the mode of curriculum delivery, we will include both synchronous and asynchronous educational content, modeling the flipped classroom approach which, when done correctly, has been proven to be an effective teaching methodology. [16] As per participant feedback, we will also incorporate hands-on experiences utilizing diagnostic tools for capacity building and skill development. Over the next 3 years, we will follow the residents through their first year of independent practice as internists to assess the longitudinal impact of the curriculum. Lastly, we hope to extend continuing cardiovascular education to general practitioners.

Given the success of this curriculum in improving cardiovascular education for IM trainees at HUM, we view this as a successful pilot study. We plan to implement the aforementioned changes and assess longitudinal impact. If there is a marked improvement, we plan to expand to additional sites to deliver much needed cardiovascular education to GPs, mid-level providers and internists in low resource settings.

Limitations:

The current study is the first to describe and present data in support of the utilization of an adaptive international cardiology curriculum delivered via an interactive and dynamic virtual classroom in Haiti. However, the study has specific limitations. The small sample size is a limitation. Given the grassroots nature of ICARDs-Haiti, it was initially launched at one teaching hospital as a pilot program which limited the sample size. Additionally, only immediate pre- and post-assessment results were obtained. Thus, although knowledge acquisition was notable among the residents at HUM, the impact on long term knowledge retention remains unclear. Language barriers were another limitation of the study. This is supported by the fact that topics taught by multilingual lecturers were more likely to be associated with moderate to large effect sizes. The fact that trainees were not separated by their training year is another limitation of the study and likely led to smaller effect sizes. Lastly, although lecture materials were reviewed by the leadership council and although the diversity of the lecturer cohort was a strength of the curriculum, variability in lecture delivery and verbal communication may have impacted the effect size for certain topics.

Conclusion:

This international cardiology curriculum is delivered via remote distance learning to meet the educational needs of physicians-in-training in Haiti. Thus far, the curriculum has been delivered to 1 of 4 IM training programs in the country.[11]By utilizing a live, dynamic, and international virtual classroom, we were able to successfully provide important cardiovascular educational content and demonstrate positive trends in knowledge acquisition through pre, post and end of the year assessments. Future directions of this

experience will lend themselves towards improving the curriculum and standardizing a component of the lecture platform. This will allow for both synchronous and asynchronous educational development that can eventually be expanded to other resource limited settings that lack cardiology training programs and specialists. In the long run, we hope that this will help to address global health disparities in cardiovascular education in resource-limited settings and serve as a valuable adjunct to onsite global health endeavors in the future.

Data Availability Statement: The authors confirm that the data supporting the findings of this study are available within the article and in the uploaded supplementary information.

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Figure 1. Effect Size Proportionality for the iCARDs-Haiti Curriculum

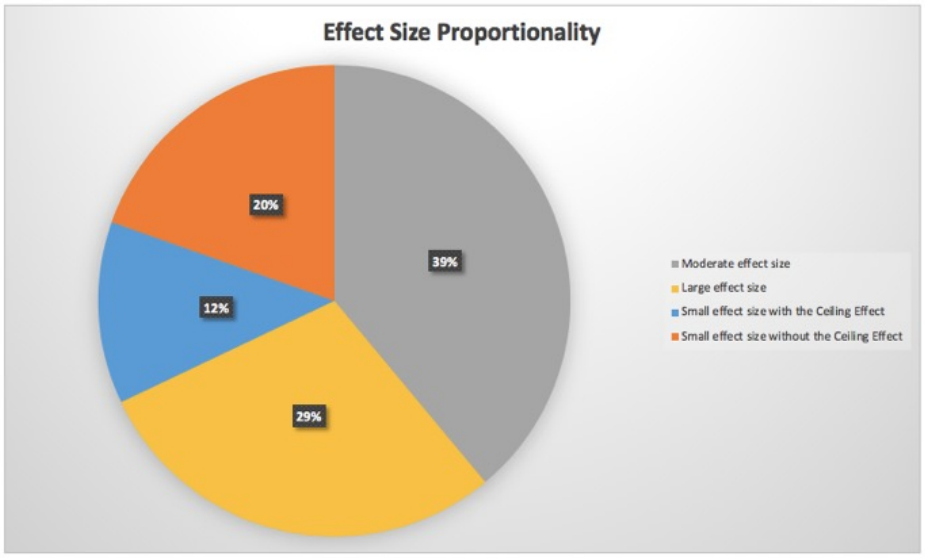


Figure 1 shows the effect size proportionality for the entire iCARDs-Haiti curriculum. As shown above, 68% of the curriculum was associated with a moderate to large effect size. 12% of the curriculum was associated with a small effect size due to the Ceiling Effect while 20% of the curriculum was associated with a small effect size not attributable to the Ceiling Effect.

260x190mm (72 x 72 DPI)

Figure 2. Effect size proportionality for topics covered in the iCARDs-Haiti Curriculum

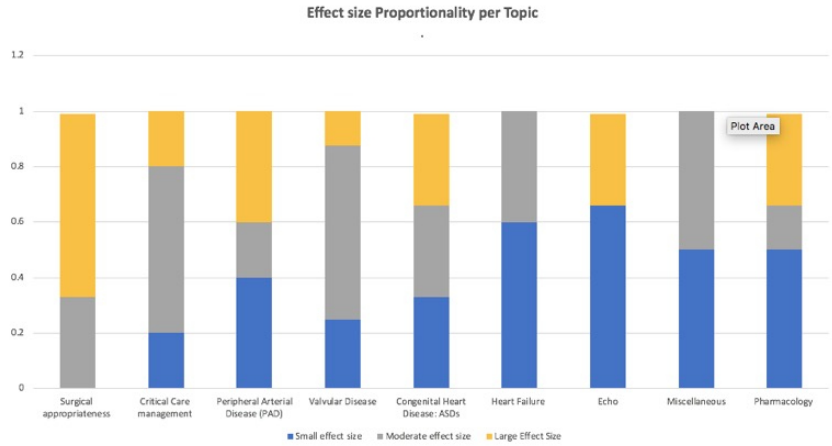
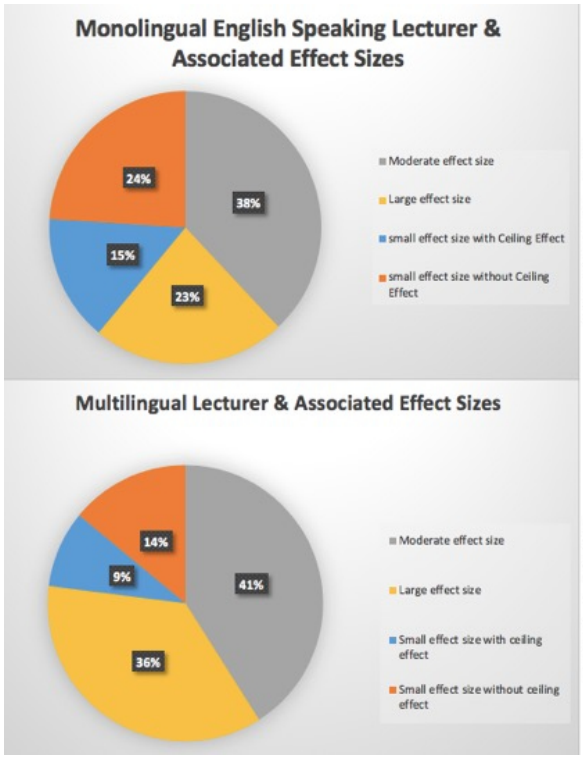


Figure 2 shows the proportion of topics associated with large, moderate and small effect sizes. The majority of surgical appropriateness, critical care management, PAD, valvular disease and congenital heart disease were associated with medium to large effect sizes. The miscellaneous category (syncope & COVID-19) had an even split between small and moderate to large effect sizes. The majority of heart failure, echo and pharmacology were associated with small effect sizes with and without the Ceiling Effect.

321x190mm (72 x 72 DPI)



Panel A shows the association between monolingual English lecturers and effect size. 61% of the topics taught by monolingual English lecturers were associated with moderate to large effect sizes. 24% percent of the topics taught by monolingual English lecturers were associated with small effect sizes not attributable to the ceiling effect.

Panel B shows the association between multilingual lecturers and effect size. 77% of the topics taught by multilingual lecturers were associated with medium to large effect sizes. 14% of the topics taught by multilingual lecturers were associated with small effect sizes not attributable to the ceiling effect.

254x190mm (72 x 72 DPI)

Table 1

Objective Assessments Associated with small effect sizes <0.3	Percent of trainees who answered objective questions correctly pre-intervention	Percent of trainees who answered objective questions correctly post-intervention	Presence of the Ceiling Effect	Fluency of the lecturers
Correctly identifying a common cause of vasovagal syncope	30%	50%	No	Multilingual
Correctly identifying COVID-19 cardiac complications	86%	100%	Yes	English, Monolingual
Correctly identifying the mechanism of action of Dobutamine	63%	88%	No	English, Monolingual
Correctly identifying the characteristics of an aortic stenosis murmur	86%	100%	Yes	English, Monolingual
Correctly identifying a normal ankle brachial index range	100%	100%	Yes	Multilingual
Correctly identifying the mechanism of action of Milrinone	57%	75%	No	Multilingual
Correctly identifying cardiogenic shock based on hemodynamic profile	57%	71%	No	Multilingual
Correctly identifying the most appropriate management of cardiogenic shock based on clinical presentation	29%	54%	No	English, Monolingual
Correctly identifying structural abnormalities associated with a longstanding atrial septal defect	70%	83%	No	English, Monolingual

Correctly identifying a hemodynamically significant Qp:Qs ratio*	60%	33%	No	English, Monolingual
Correctly identifying all heart failure guideline directed medical therapies*	77%	75%	No	English, Monolingual
Correctly dosing Dopamine for cardiogenic shock *	71%	50%	No	English, Monolingual
Correctly identifying the definition of the continuity equation *	83%	71%	No	English, Monolingual
Subjective Confidence assessments associated with small effect sizes <0.3	Percent of trainees who were either comfortable or very comfortable on the rating scales pre-intervention	Percent of trainees who were either comfortable or very comfortable on the rating scales post-intervention	Presence of the Ceiling Effect	Fluency of the Lectures
Comfort with guideline directed medical therapy for heart failure	100%	100%	Yes	English, Monolingual
Comfort with performing a heart failure history and physical exam	100%	100%	Yes	English, Monolingual
Comfort with identifying standard echo views	100%	100%	Yes	English, Monolingual
Comfort identifying risk factors for peripheral arterial disease	83.30%	100%	Yes	Multilingual
Comfort managing aortic insufficiency	50%	85.70%	No	English, Monolingual

*Negative small effect sizes

Appendix Table 1

Yellow=Large effect, Gray=Medium effect, Blue=Small Effect

*Objective Assessments

	Effect Size:
Surgical appropriateness	
Knowing the criteria for ASD repair	0.63
Knowing when to refer patients with MS for corrective interventions	0.57
Familiarity with the Wilkins score	0.36
Knowing when to refer patients with MR for corrective intervention	0.46
knowing when to refer patients with AI to surgery	0.48
comfort performing a pre-operative assessment	0.63
Knowing which surgeries are considered low, intermediate and high risk	0.52
Ability to Identify appropriate work-up for low risk surgical candidates*	0.82
Ability to identify appropriate work-up for high risk surgical candidate*	0.63
Critical Care management	
knowing the pathophysiology of cardiogenic shock	0.33
comfort with the management of cardiogenic shock	0.48
knowing the different types of mechanical assist devices used to treat cardiogenic shock	0.34
knowing the hemodynamics of cardiogenic shock	0.48
Knowing when to refer patients for invasive hemodynamic monitoring (RHC)	0.79
Confidence in recognition of normal hemodynamic tracings	0.48
Ability to identify the most appropriate management of cardiogenic shock*	0.26
Ability to correlate a hemodynamic profile with the correct type of shock*	0.12
Ability to identify the p/f ratio indicative of severe ARDS*	0.56
Ability to identify the most appropriate management for septic shock *	0.48
PAD	
comfort with managing PAD	0.76
Confidence in differentiating chronic from acute limb ischemia	0.46
familiarity with the risk factors for PAD	0.24
Knowing how to measure an ABI	0.52
Ability to identify the normal ABI range *	0
Valvular Disease	

Comfort with the anatomy of the mitral valve	0.4
Comfort with the medical management of MR	0.64
Comfort identifying a MS murmur	0.37
Knowing the causes of mitral stenosis	0.36
Comfort with the management of MS	0.34
comfort with the management of AI	0.21
Ability to identify the correct description of an AS murmur*	0.23
Ability to identify the AVA for severe AS*	0.49
Congenital Heart Disease: ASDs	
Comfort quantifying a cardiac shunt using the Qp/Qs equation	0.6
Knowing the different types of ASDs	0.58
Ability to identify the EKG finding commonly associated with an ASD*	0.49
Ability to identify cardiac defects frequently seen with ASDs*	0.34
Ability to identify structural abnormalities associated with longstanding ASDs*	0.13
Ability to correctly identify a hemodynamically significant Qp:Qs ratio*	0.23
Heart Failure	
Comprehension of HF pathophysiology	0.39
Comfort with interpretation of the HF exam	0.38
Knowing GDMT for HF	0.27
Comfort performing a H&P on a HF patient	0.15
Ability to identify GDMT*	0.02
Echo	
Comfort identifying standard echocardiography views	0.13
Demonstrating an understanding of the continuity equation *	0.11
Ability to calculate AVA based on echo parameters*	0.54
Miscellaneous	
Knowing the differential diagnosis for syncope	0.4
Knowing the work-up for syncope	0.39
Ability to identify COVID-19 cardiac complications*	0.24
Ability to correctly identify a common provocation of vasovagal syncope*	0.19
Pharmacology	
Ability to identify the mechanism by which Digoxin decreases HR*	0.37
Ability to identify the mechanism of action of Nipride *	0.57
Ability to identify how dopamine is cleared*	0.73
Ability to identify appropriate dopamine dosing for cardiogenic shock*	0.19

Ability to identify the mechanism of action of milrinone *	**0.16**
Ability to identify the mechanism of action of Dobutamine*	**0.26**

Sample Subjective Assessment Question with Associated Answer choices:

1. I know when to refer a patient with mitral stenosis for corrective intervention
    A. Strongly Agree
    B. Agree
    C. Neither agree nor Disagree
    D. Disagree
    E. Strongly Disagree

Sample Objective Assessment Question with Associated Answer choices:

2. What echocardiography finding would you expect to see with a longstanding ASD?
    A. Hypertrophied RV
    B. Dilated LV
    C. Hypertrophied LV
    D. Dilated RV

BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-048690.R1
Article Type:	Original research
Date Submitted by the Author:	28-Apr-2021
Complete List of Authors:	Haynes, Norrisa; University of Pennsylvania, Cardiology Saint-Joy, Veauthyelau ; Centre Hospitalier d Antibes Juan les Pins, Cardiology Swain , JaBaris; University of Pennsylvania, Cardiovascular Surgery Ezekwesili, Agnes; University of Pennsylvania Perelman School of Medicine Vernet, Fritz; Hôpital Universitaire de Mirebalais, Internal Medicine Dawson , Calixte; Hôpital Universitaire de Mirebalais, Internal Medicine Laneau, Davidson; Hôpital Universitaire de Mirebalais, Internal Medicine Tierney, Ann; University of Pennsylvania, Center for Clinical Epidemiology and Biostatistics Shea, Judy ; University of Pennsylvania, Division of General Internal Medicine Ambrose , Marietta; University of Pennsylvania, Cardiology
Primary Subject Heading:	Cardiovascular medicine
Secondary Subject Heading:	Global health, Medical education and training
Keywords:	MEDICAL EDUCATION & TRAINING, CARDIOLOGY, PUBLIC HEALTH

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The Implementation of a Virtual International Cardiology Curriculum to Address the Deficit of Cardiovascular Education in Haiti: A Pilot Study

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Word Count: 3533

Acknowledgements: Special thank you to the internal medicine residents at Hôpital Universitaire de Mirebalais, Dr. Jean-Pierre Brisma, Zanmi Lasante, Dr. Merly Robert, Dr. Gene Kwan, UPenn cardiology fellows, Glenn Gaulton, Penn Global Health, Dr. Garly Saint-Croix, Dr. Michel Ibrahim, Dr. Benedicte LeFevre, Dr. Yann Dagher-Hayck, Dr. Duarxy R. Sainvilien, Dr. Anne Christine Buteau, Dr. Krystal Hill, Dr. Frank Silvestry, Dr. Paul Mather, Dr. Victor Ferrari, Dr. Thomas Cappola, Dr. Joyce Wald, Dr. Mahesh Vidula, Dr. Sri Adusumalli, Denice Susini, Jennifer Cronin. Special thank you to the Penn Cardiovascular Disease Fellowship Innovation Fund for statistical support.

Author contributions:

N.H., V.S.J., conceived and planned the study. N.H., V.S.J., F.V.V., C.D., D.L., and M.A., carried out the study. N.H., V.S.J., performed data collection. A.T., N.H., V.S.J., J.B., M.A., J.A.S., performed data analysis and interpretation. N.H., J.B., V.S.J., drafted the manuscript. M.A., J.S.A., A.E., performed critical revision of the article. N.H., V.S.J., J.B., A.E., F.V.V., C.D., D.L., A.T., J.A.S., and M.A., approved the article to be published.

Funding: There is no funding to report
Disclosures: There are no relationships with industry to report. All authors have nothing to disclose
Ethics Approval Statement: IRB exemptions were obtained from the Zanmi Lasante/HUM IRB committee (ID: ZLIRB04062020) and the University of Pennsylvania IRB committee (ID: ddbcggaj). Participants gave informed consent to participate in this study.

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Abstract:
Background: Cardiovascular disease (CVD) remains a leading cause of morbidity and mortality worldwide, conferring a disparate burden on low and middle-income countries (LMICs). Haiti represents a resource-constrained setting, limited by a paucity of resources and trained cardiovascular professionals equipped to address the increasing burden of CVD.

Objective: Here we describe the creation of a comprehensive cardiology curriculum delivered through a virtual classroom. The curriculum was created to augment cardiovascular education in LMICs such as Haiti.

Methods: Over one academic year (May 2019-2020), ICARDs-Haiti consisted of biweekly, live-streamed, synchronous didactic lectures, seminars and case presentations broadcasted to 16 internal medicine (IM) residents at Hôpital Universitaire de Mirebalais (HUM), 1 of only 4 IM training programs in Haiti. The virtual classroom was created using commercially available video conferencing and data-sharing platforms. Pre- and post-lecture surveys and an end of the year survey were administered to assess the impact of the curriculum.

Results: Participant performance analysis revealed that 80% of the curriculum demonstrated a positive trend in knowledge acquisition post-intervention. Based on the end of the year evaluation, 94% of participants reported that the curriculum was educational and relevant to medical practice

in Haiti and 100% reported that the curriculum was good to excellent. Additionally, the curriculum was cited as an effective means of maintaining trainee education during the COVID-19 pandemic.

Conclusion: This international medical education pilot study demonstrates the feasibility of augmenting cardiology education in LMICs by creating a virtual curriculum made possible by local partnerships, internet access, and technology.

Article Summary:

Strengths:

1) The application of the ADDIE (Analysis, design, development, implementation and evaluation) instructional framework enabled a methodical and iterative approach to the development and implementation of an international curriculum.
2) Objective knowledge and subjective comfort assessments enabled measurement of knowledge acquisition and improvement in self-reported comfort with the management of cardiovascular patients.
3) Partnership among Haitian, American and French health professionals in the design, development and implementation of the curriculum helped to ensure that the curriculum was applicable to providers in low resource settings such as Haiti.

Limitations of the study:

1) Given that the initial implementation of the pilot occurred at one training site, the sample size is small.
2) The use of immediate post-lecture assessments limited the ability to understand program influence on long-term knowledge retention.

Keywords: *Haiti, international cardiology curriculum, global health, distance learning*

Introduction:

Cardiovascular disease (CVD) accounts for 29% of all deaths in Haiti, and the incidence of peripartum cardiomyopathy is one of the highest in the world at a rate of 1 in every 300 deliveries.[1,2] Haiti also has a relatively high prevalence of rheumatic heart disease (RHD) at 5% in rural settings and a high prevalence of hypertensive cardiomyopathy and stroke.[3,4] There is also a lack of cardiovascular healthcare infrastructure. Although most hospitals have access to EKG machines, there are no catheterization laboratories in the country. Acute coronary syndromes

(ACS) are typically managed medically. There is limited access to cardiac surgery through non-governmental organizations (NGOs). Additionally, due to a lack of trained professionals, few hospitals routinely use echocardiography despite its high diagnostic value.

Currently, there are only 16 cardiologists countrywide for a population of over 11 million people.[4,5] There are no formal cardiology training programs in Haiti. The 16 cardiologists who currently work in Haiti received their training outside of the country given the absence of domestic postgraduate training programs in cardiovascular disease. Many obtained formal cardiology fellowship training in countries such as France, Cuba and the United States of America (USA). Given the lack of training opportunities and cardiologists in the context of high CVD burden, it is apparent that there is a need for additional cardiovascular education support for healthcare providers both in and out of training programs.

Hôpital Universitaire de Mirebalais (HUM) is 1 of only 4 Internal Medicine (IM) residency programs in Haiti, training an estimated 20-25% of all IM residents in the country.[6] HUM is one of the largest teaching hospitals and one of the only to receive accreditation from the Accreditation Council for Graduate Medical Education International (ACGME-I).[7] It has an integrated public and private structure with a robust partnership with Haiti's Ministry of Health. Its structure enables it to be both affordable and accessible to the general public. HUM also has access to imaging modalities such as ultrasound making echocardiography possible. Patients travel long distances to seek treatment for some of the most advanced diseases and severe pathology. This holds true for cardiovascular patients with nearly 40% of all admissions to the internal medicine ward being for heart failure and 60% of those heart failure admissions being women.[3] Despite the high prevalence of CVD among hospitalized patients at HUM, access to cardiologists is limited. Thus, the IM residents are left to care for these patients without access to optimal cardiovascular education and support.

To assist the cardiovascular needs at HUM, one of the largest teaching hospitals which serves a sizable catchment area, we developed a virtual pilot educational program entitled ICARDs-Haiti (International Cardiology Curriculum Accessible by Remote Distance Learning) to deliver an adaptive cardiovascular curriculum to IM residents at HUM. Initially developed and executed before the onset of the COVID-19 pandemic, the purpose of ICARDs-Haiti has evolved. The value and goals of the curriculum are now two-fold: to provide pertinent educational material and to maintain educational activities during the ongoing COVID-19 pandemic in Haiti. Here, we describe a pilot intervention and first attempt at bridging the cardiovascular education divide in a resource-limited setting through the execution of a virtual classroom utilizing live-streamed lectures and an interactive discussion format.

Methods:

In May 2019, ICARDs-Haiti was created by a chief resident at Hôpital Universitaire de Mirebalais (who is now a cardiology trainee in France) and a University of Pennsylvania (UPenn) Cardiology fellow under the auspices of the educational leadership from their respective institutions. Thereafter, a formal international collaboration between HUM physicians and UPenn cardiologists was forged with the objective to create a dynamic, adaptive and comprehensive curriculum that included locally relevant and useful educational cardiology content. IRB exemptions were obtained from the Zanmi Lasante/HUM and UPenn IRB committees.

Prior to initiating ICARDs-Haiti, the cardiology curriculum at HUM was undergoing significant restructuring due to the lack of a full-time cardiovascular specialist. The HUM IM faculty created a list of pertinent cardiovascular topics. They planned for oral presentations by residents and a weekly academic discussion with a local cardiologist. Despite these aspirations, in practice, the amount of time that local cardiovascular specialists were able to commit to education at HUM was limited. Additionally, travel restrictions that were imposed due to political instability (and later the COVID-19 pandemic) prohibited travel of visiting cardiologists from the USA and Europe to support trainees and faculty at HUM. The consequence of these limitations was a lack of routine, consistent and comprehensive cardiovascular education despite the high CVD burden among HUM patients. Due to the need for improved and continual cardiovascular education, HUM chief residents and a HUM-affiliated, local cardiologist sought assistance in creating a more consistent and comprehensive cardiology curriculum for HUM's trainees by soliciting assistance from colleagues abroad who had spent significant time in Haiti. A global network of medical educators was subsequently created to address this need.

Through international collaboration, a revised list of pertinent cardiology topics and respective learning objectives was created. The American College of Cardiology (ACC) core competency recommendations for cardiology trainees were also used as a guide. Volunteer lecturers consisted of cardiology fellows, attendings and internists from UPenn, Boston University, Mount Sinai Medical Center in Miami, New York University (NYU), SUNY Downstate and Centre Hospitalier d'Antibes Juan-les-Pins (Provence Alpes Côtes d'Azur, France). Many of the lecturers had personal ties to Haiti and were also multilingual. Lectures were given in either English, French, Haitian Creole or a mixture of these languages. The assessed curricular content was created and delivered by 8 lecturers 50% of whom were multilingual. The vast majority of IM residents at HUM are fluent in English, French and Haitian Creole, although English comprehension skills are variable. The curriculum was implemented using the ADDIE training model (Analysis, Design, Development, Implementation, Evaluation), an instructional design methodology.[8] It is currently being used as a guide for the implementation and adaptation of this curriculum based on written and verbal feedback from the IM residents.

Lectures were delivered biweekly via video conference platforms, and each lecture was preceded and followed by anonymous, unmatched pre- and post-knowledge assessments. The assessments

were delivered via the Qualtrics program and distributed via a commercially available, internet-based mobile phone communication application. Lecture reading materials were distributed via SLACK (Searchable Log of All Conversation and Knowledge), an online communication platform. The cardiovascular topics and learning objectives for the curriculum were determined by a leadership council which consisted of cardiovascular fellows and faculty at UPenn as well as the IM program director and the chief residents at HUM and a local Haitian cardiologist. The content for each lecture was created by volunteer lecturers from the aforementioned institutions and was reviewed by the leadership council. The live-streamed lectures were supplemented with case presentations, seminars and included active audience participation. The cardiology topics covered in the curriculum are shown in Table1. For most of the topics, the following content was provided: physiology, pathophysiology, clinical presentation, physical exam findings, medical management and indications for interventional procedures and surgery.

Table 1:
ICARDS 2019 – 2020

Curriculum	Topics		Frequency of sessions	Number of lectures
	Stenotic valvular lesions,	Congenital heart disease (CHD)	Bi-Weekly	20
	Regurgitant valvular lesions	Atrial septal defects		
	Heart failure (HF)	Peripheral arterial disease (PAD)		
	Peripartum cardiomyopathy (PPCM),	Syncope		
	Cardiogenic shock	Hypertension		
	Pharmacology of HF medications	Interactive EKG conferences		
	Preoperative work-up	Perioperative medication management		

	Interpretation of basic echocardiography		
Medical/ Surgical subcategories	Critical care management		
	Surgical appropriateness		
Supplemental topic	Acute respiratory distress syndrome (ARDS) - in context of the COVID-19 pandemic.		

The ICARDs curriculum was integrated into the trainees' pre-existing didactic schedule. Thus, all 16 residents participated in this 1-year research study. Sessions were held on Monday evenings for one hour. Surveys included subjective confidence rating assessments typically with 5 answer choices that most commonly ranged from strongly disagree to strongly agree. Objective assessments took the form of multiple-choice questions with correct and incorrect answers (Appendix Table 1).

Patient and Public Involvement: Patients or the public were not involved in the design, or conduct, or reporting, or dissemination of this research.

Statistical analysis:
Statistical analysis was performed using SAS software. The Wilcoxon Mann-Whitney U-test was used for data analysis due to the non-parametric nature of the data and the small sample size. Cohen's (r) was used to estimate effect sizes. Effect sizes ranging from 0.1 to <0.3 were interpreted as small, effect sizes ranging from 0.3 to <0.5 were interpreted as moderate, and effect sizes of 0.5 and greater were interpreted as large.[9]

Results:
Between May 2019 and May 2020, there were 16 IM residents at HUM of whom 20% were women and 80% were men. There were 6 first year residents, 5 second year residents and 5 third year residents. The ages of the IM residents ranged from 25-30 years old. Analysis of 56 items (Appendix Table 1) revealed that 32% of the assessed curricular content was associated with a small effect size, 39% was associated with a moderate effect size and 29% was associated with a

large effect size. The small effect size category was further subdivided into a small effect size due to the Ceiling Effect and a small effect size without the Ceiling Effect. We defined the Ceiling Effect as subjective or objective assessments associated with a small effect size <0.3 for which the post-assessments had perfect scores (the ceiling). The percentage of the curriculum with a small effect size with and without the Ceiling Effect was 12% and 20% respectively (Figure 1). When the 56 items were analyzed based on topic category, we found that the majority of the effect sizes for surgical appropriateness, critical care management, PAD, valvular disease and CHD were moderate to large suggesting that these topics had more of an impact (Figure 2). In contrast, HF, echocardiography, and pharmacology had a larger proportion of small effect sizes implying that there was no meaningful difference between the pre- and post-assessments (Figure 2).

A notable proportion of the small effect sizes was due to the Ceiling Effect with high pre-assessment scores and post-assessment scores of 100% (Appendix Table 2). Additionally, Figure 3 shows that topics taught by monolingual English speakers were associated with a higher proportion of small effect sizes without the Ceiling Effect (24%) when compared to lectures provided by multilingual lecturers (14%) shown in Figure 4. Four objective assessments; comprehension of the continuity equation, appropriate dosing of dopamine for cardiogenic shock, identifying a hemodynamically significant Qp:Qs ratio (shunt fraction), and correctly identifying all guideline directed medical therapy (GDMT) for HF, were associated with small negative effect sizes, due to a slightly higher proportion of students answering the objective questions correctly prior to the intervention. Notably, these topics were taught by monolingual English Speakers (Appendix Table 2).

All participants completed an end-of-the year survey. When asked whether the material covered by the curriculum was relevant to medical practice in Haiti, 56.3% of participants agreed and 37.5% strongly agreed for a total of 94% agreeing that the material was relevant. When asked about the commitment of the course directors, 12.5% of participants reported the commitment as good and 87.5% as very good to excellent. In the context of clearly delineated learning objectives, all participants reported learning what they expected from the curriculum with 46% reporting that the curriculum exceeded their learning expectations. For the overall evaluation of the course, all participants reported that the course was good to excellent. When asked if they would like to incorporate recorded lectures into the curriculum, 25% of participants reported that they preferred only live lectures, 75% preferred a mix of live and pre-recorded lectures and 0% preferred only pre-recorded lectures.

When asked how the curriculum could be improved, participants recommended streamlining the lectures, increasing the number of practice questions, incorporating French and Haitian Creole verbal or written translation into the lectures and implementing a hands-on echocardiography experience. Participants identified a number of strengths which included but were not limited to the diversity of lecturers, incorporation of French and Haitian Creole into some of the lectures, the

relevance of the content to medical practice in Haiti, the amount of material learned and the pre- and post-lecture questions as pertinent learning aids to reinforce retention of the information presented in the lectures.

Discussion:

In an attempt to address the deficiency of formal cardiovascular education and routine access to cardiologists in Haiti, a virtual, collaborative, international cardiology curriculum for IM trainees was created at HUM, where nearly 40% of all admissions to the medical ward are due to CVD.[3] Analysis results suggest that the curriculum has been impactful. Accordingly, 68% of the assessed curriculum had a moderate to large effect size indicating a noteworthy educational impact based on pre- and post-lecture assessments. When small effect sizes due to the Ceiling Effect are included, 80% of the curriculum demonstrates a positive trend in knowledge acquisition post-intervention. Furthermore, all participants completed the end of the year general assessment for which the overall rating of the curriculum was good to excellent.

The topics associated with moderate to large effect sizes included surgical appropriateness, critical care management, PAD, CHD and valvular heart disease. After completing the curriculum learning objectives, trainees felt more confident in their ability to identify indications for interventional procedures and surgical intervention for valvular disease and CHD. Trainees were also more confident in knowing when to appropriately refer patients to cardiovascular specialists for corrective interventions. Additionally, trainees demonstrated an improvement in the objective assessments of preoperative risk, medical management of valvular disease and critical care management. An improvement in the assessment scores of the aforementioned topics is important given the high prevalence of RHD and severe HF among patients admitted to HUM. Based on a study by Kwan et al. from 2016, 37% of all HUM admissions were for HF and more than 60% of HF patients were women.[3] Of those women with cardiomyopathy, 50% were diagnosed with PPCM.[3] Five percent of cardiovascular admissions were due to RHD with notable valvular disease identified by echocardiography.[3] Notably, although access to cardiac surgery is limited, organizations such as the Haiti Cardiac Alliance (HCA) work to facilitate surgical referrals and long-term follow up for cardiac surgery patients in Haiti.[10] Thus, educating GPs and internists on timely referral of cardiovascular patients to specialists and entities equipped to provide specialized care, as well as corrective interventions, can improve cardiovascular outcomes for patients with severe CVD in Haiti.

The topics associated with a large proportion of the small effect sizes are shown in Figure 2. Many of the small effect sizes were explained by trainees' pre-existing medical knowledge and comfort with those topics. One reason that trainees may have scored highly on a number of the pre-assessments could be from prior exposure to these topics, before ICARDs-Haiti curriculum implementation. Additionally, trainees were not separated by their training year. Senior residents

were likely to be more familiar with some of these topics than junior residents were, thereby, creating smaller effect sizes than if trainees had been separated by their training year. Four topics (shunt fraction, continuity equation comprehension, HF guideline-directed medical therapy, and Dopamine dosing) were associated with small negative effect sizes. All 4 of these assessments were objective and were taught only in English without French or Haitian Creole translation. Thus, the lack of a positive and moderate to large effect size for these topics is likely multifactorial and causality may include a lack of content clarity, topic complexity and language comprehension. A larger proportion of topics taught by multilingual lecturers with personal ties to Haiti, were associated with moderate to large effect sizes. Studies have demonstrated the effect of culture and language on online learning including how linguistic barriers and academic culture can negatively impact the academic success of non-English speakers.[11,12] This observation highlights the importance of not only language, but also cultural contextualization for learning.

Specific considerations were made to ensure that the curriculum was applicable to providers practicing in Haiti. Health professionals from Haiti participated in the design, development and implementation of the curriculum. These collaborations enabled an understanding of specific resource limitations that were taken into account when creating the curriculum. The inclusion and active participation of Haitian health professionals reinforced culturally responsive teaching, which likely mitigated cultural barriers.[13] Their participation enabled a real-world application of the curriculum that helped to fill an educational void that hopefully also enhanced peer-to-peer education. Additionally, the prevalence of various cardiovascular diseases in Haiti was used to prioritize topics. Lastly, feedback from the residents was obtained to improve the quality and relevance of the curriculum content.

Looking ahead, there are plans to modify the ICARDs curriculum to better address the educational needs in this region. Written or verbal French or Haitian Creole translation will be provided for all future lectures. For the topics associated with small effect sizes without the Ceiling Effect, these lectures will be restructured to improve clarity. For the topics associated with small effect sizes with the Ceiling Effect (implying that the trainees were already familiar with the topics), there will be a refocus of educational efforts on other higher yield topics. Learning objectives for various topics will be stratified by training year. To improve the objective assessment results, homework assignments which will be reviewed in smaller interactive summer sessions to support comprehension of complex topics. Drumford et. al., measured increased student engagement from collaborative team and seminar modalities in online learning, highlighting their import in the acquisition of group skills and needful student-faculty interactions. [14] To diversify the mode of curriculum delivery, we will include both synchronous and asynchronous educational content, modeling the flipped classroom approach which, when done correctly, has been proven to be an effective teaching methodology .[15–17] Additionally, other quantitatively proven methods for augmented remote learning such as discussion boards, chat rooms, and interactive guided problem solving are being explored for integration into the curriculum. [14] As per participant feedback,

hands-on experiences utilizing diagnostic tools for capacity building and skill development will be implemented. Additionally, residents will be followed longitudinally for 3 years into their first year of independent practice as internists to assess the longitudinal impact of the curriculum.

This pilot study was a success given the establishment of an international collaboration that succeeded in creating a dynamic curriculum that augmented cardiovascular education for IM trainees in Haiti. To improve the curriculum, the aforementioned changes will be made, and longitudinal impact will be measured. If there is a marked improvement, ICARDs will be expanded to additional sites to deliver much needed cardiovascular education to general practitioners, mid-level providers and internists in low resource settings.

Limitations:

The current study is the first to describe and present data in support of the utilization of an adaptive international cardiology curriculum delivered via an interactive and dynamic virtual classroom in Haiti. However, the study has specific limitations. The small sample size is a limitation. Given the grassroots nature of ICARDs-Haiti, it was initially launched at one teaching hospital as a pilot program which limited the sample size. Additionally, only immediate pre- and post-assessment results were obtained. Thus, although knowledge acquisition was notable among the residents at HUM, the impact on long term knowledge retention remains unclear. Additionally, language differences were associated with lower assessment performance. This is supported by the fact that topics taught by multilingual lecturers were more likely to be associated with moderate to large effect sizes. The fact that trainees were not separated by their training year is another limitation of the study and likely led to smaller effect sizes. Lastly, although lecture materials were reviewed by the leadership council and although the diversity of the lecturer cohort was a strength of the curriculum, variability in lecture delivery and verbal communication may have impacted the effect size for certain topics.

Conclusion:

The alarming increase in the global burden of CVD provides compelling evidence in support of prioritizing urgent, yet, carefully planned efforts to support cardiovascular medical education in LMICs such as Haiti. By utilizing a live, dynamic, and virtual classroom, this international cardiology curriculum demonstrated positive trends in knowledge acquisition through pre, post and end of the year assessments. This accomplishment is noteworthy given the grassroots effort among Haitian, American and French cardiology trainees and faculty to support cardiovascular educational capacity in one of the most under resourced countries in the world despite cultural and socio-economic barriers. Future directions of this experience will lend themselves towards improving the curriculum and standardizing a component of the lecture platform. This will allow for both synchronous and asynchronous educational development that can eventually be expanded to other resource limited settings that lack cardiology training programs and specialists. In the long run, the hope is that this will help to address global health disparities in cardiovascular education

in resource-limited settings and serve as a valuable adjunct to onsite global health endeavors in the future.

Data Availability Statement: The authors confirm that the data supporting the findings of this study are available within the article and in the uploaded supplementary information.

Figure Legends/Captions:

Figure 1 Legend:

Figure 1 shows the effect size proportionality for the entire ICARDs-Haiti curriculum. As shown above, 68% of the curriculum was associated with a moderate to large effect size. 12% of the curriculum was associated with a small effect size due to the Ceiling Effect while 20% of the curriculum was associated with a small effect size not attributable to the Ceiling Effect.

Figure 2 Legend:

Figure 2 shows the proportion of topics associated with large, moderate, and small effect size. The majority of surgical appropriateness, critical care management, peripheral arterial disease, valvular disease and congenital heart disease were associated with medium to large effect sizes. The miscellaneous category (syncope and COVID-19) had an even split between small and moderate to large effect sizes. The majority of heart failure, echo and pharmacology were associated with small effect sizes with and without the Ceiling Effect.

Figure 3 Legend:

Figure 3 shows the association between monolingual English lecturers and effect size. 61% of the topics taught by monolingual English lecturers were associated with moderate to large effect sizes. 24% of the topics taught by monolingual English lecturers were associated with small effect sizes not attributable to the Ceiling to Effect.

Figure 4 Legend:

Figure 4 shows the association between multilingual lecturers and effect size. 77% of the topics taught by multilingual lecturers were associated with medium to large effect sizes. 14% of the

topics taught by multilingual lecturers were associated with small effect sizes not attributable to the Ceiling Effect.

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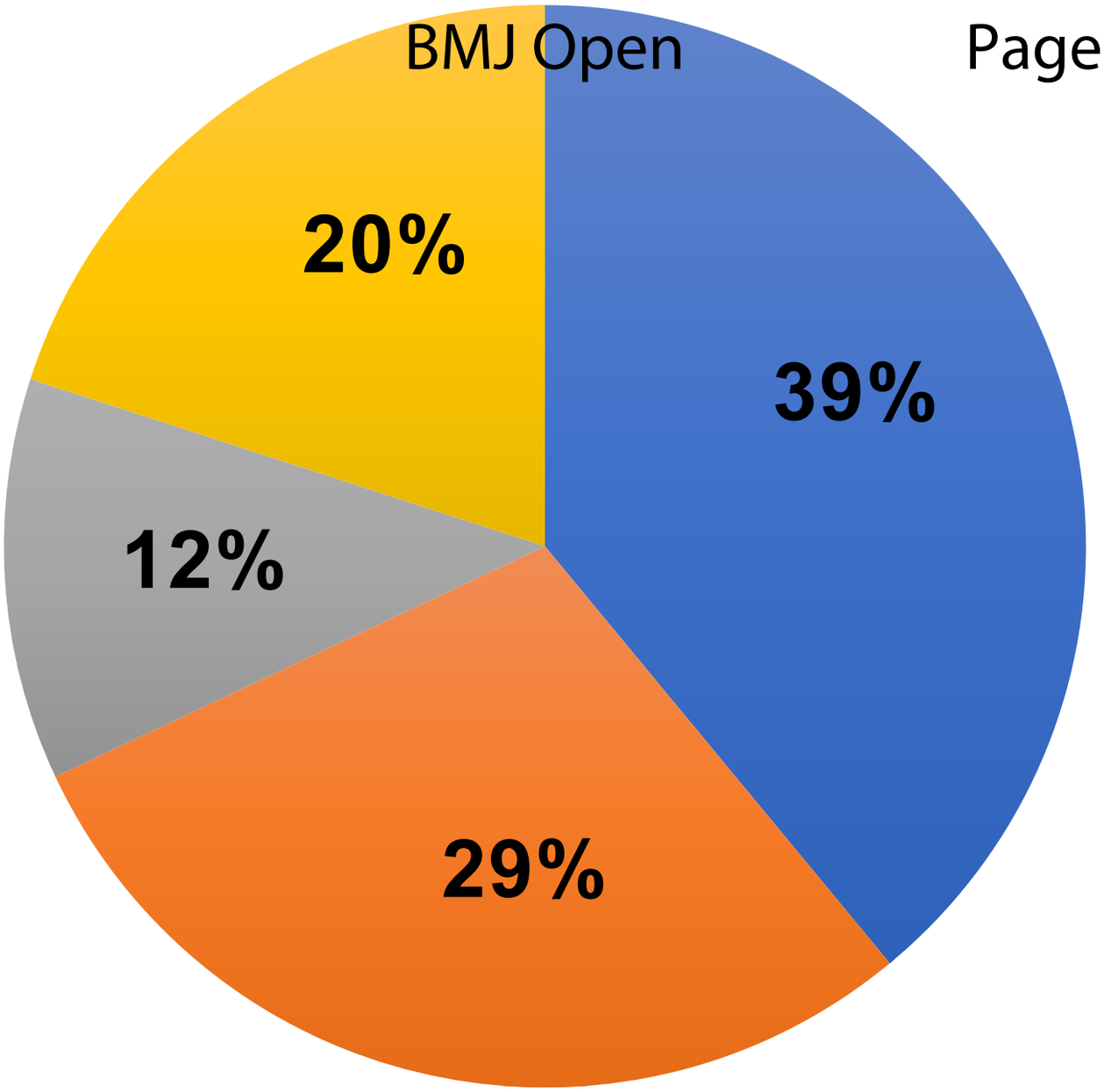

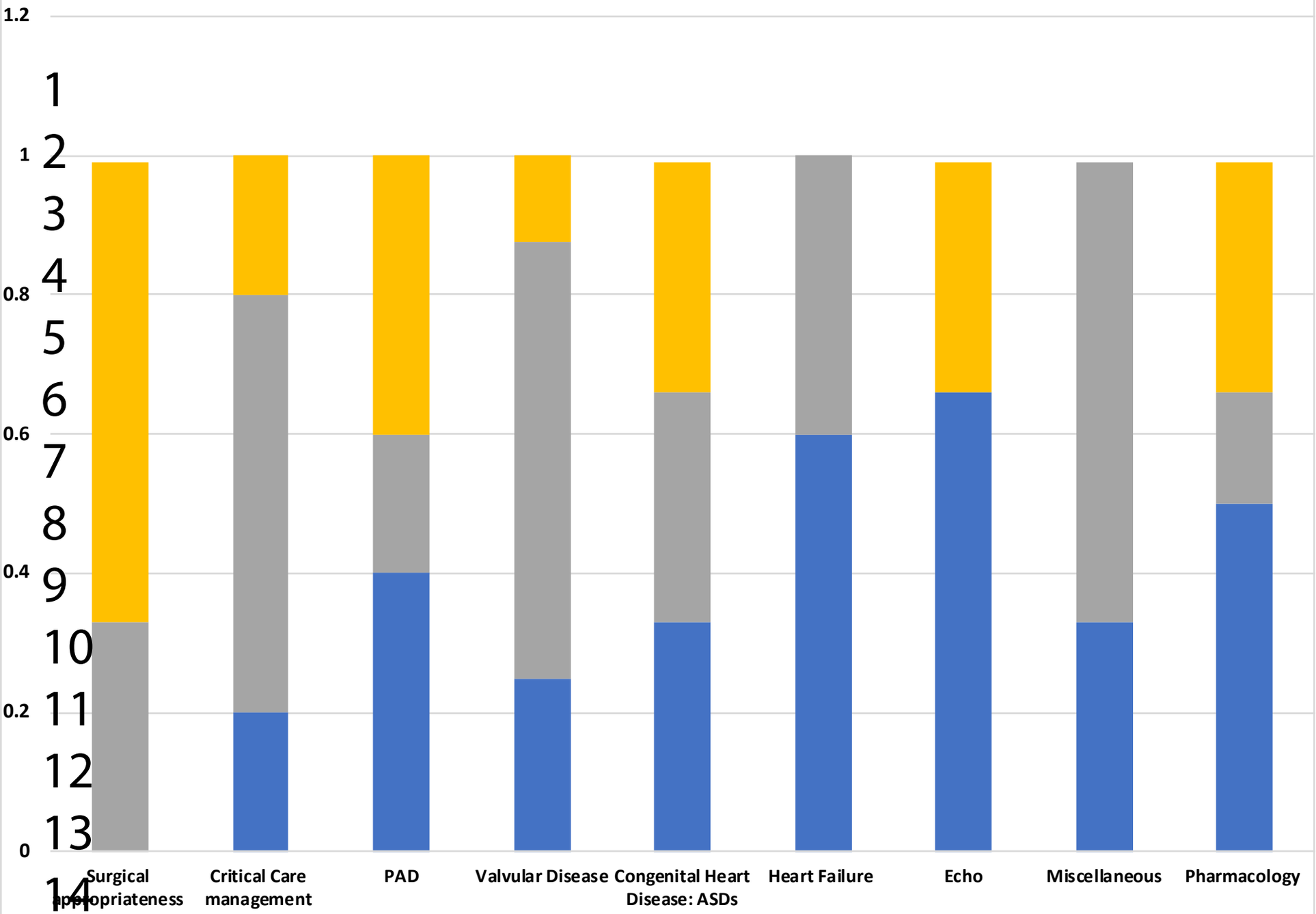

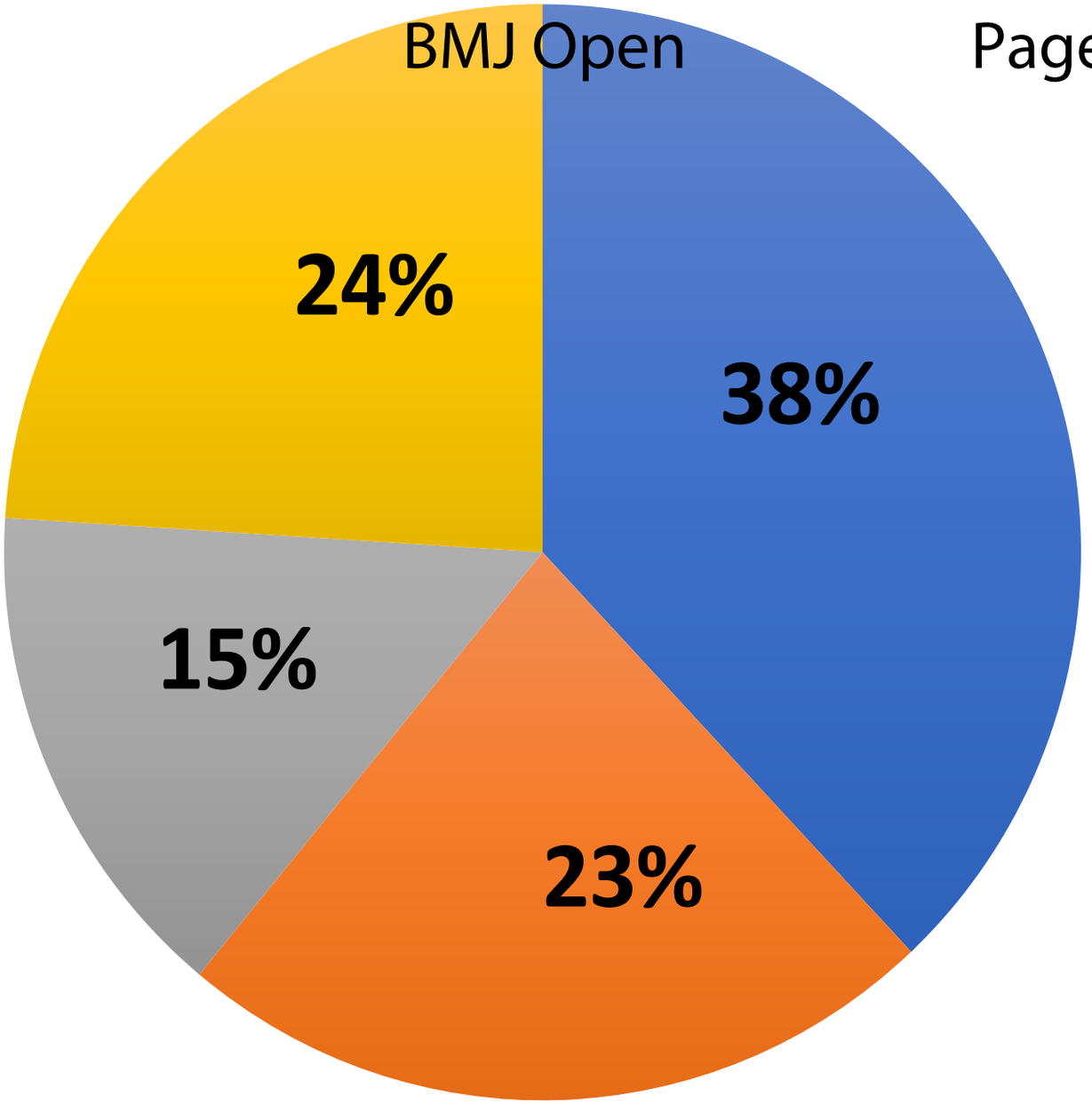

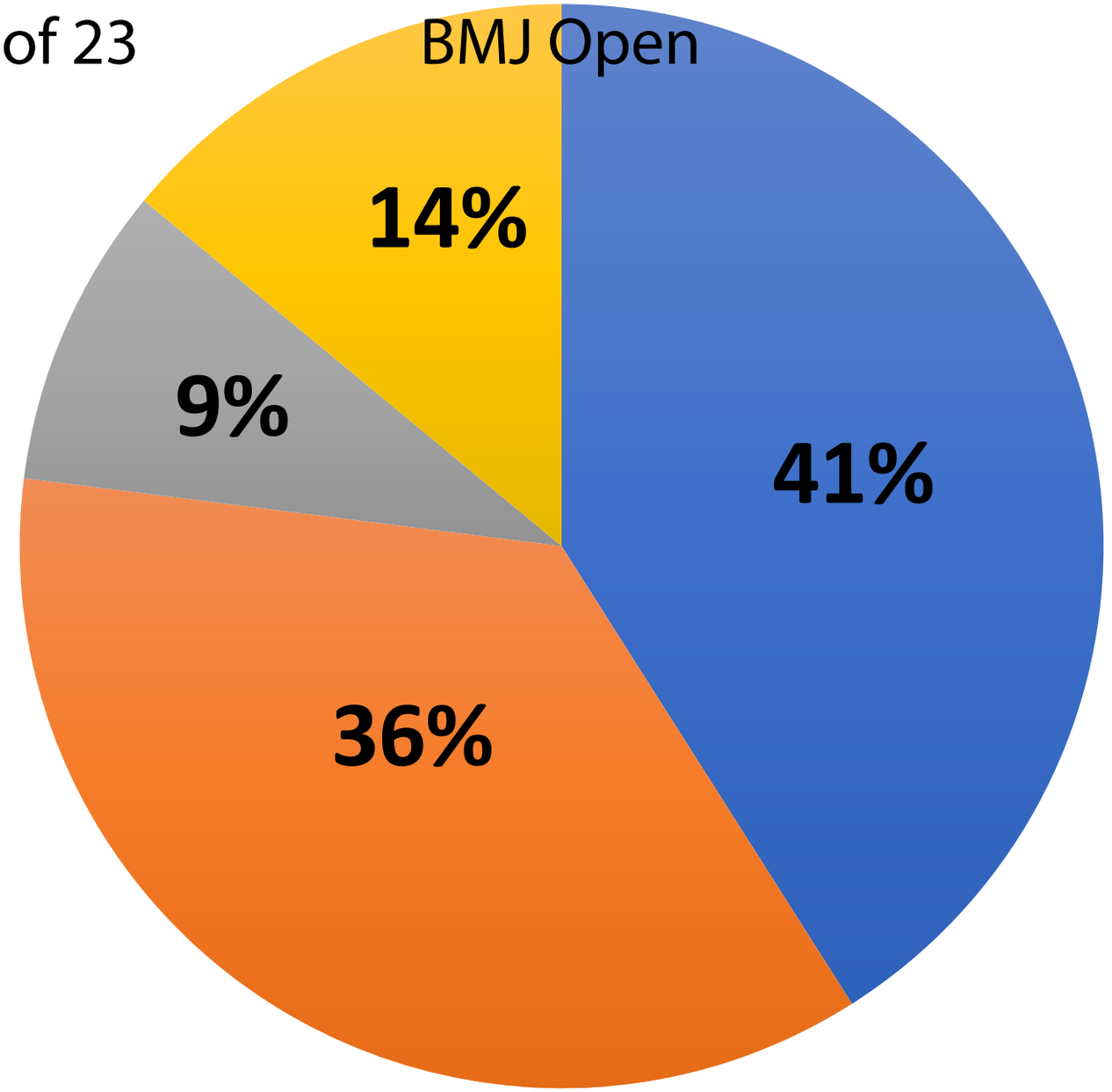

Appendix Table 1

Yellow=Large effect, Gray=Medium effect, Blue=Small Effect

*Objective Assessments

Surgical appropriateness	**Effect Size:**
Knowing the criteria for ASD repair	0.63
Knowing when to refer patients with MS for corrective interventions	0.57
Familiarity with the Wilkins score	0.36
Knowing when to refer patients with MR for corrective intervention	0.46
knowing when to refer patients with AI to surgery	0.48
comfort performing a pre-operative assessment	0.63
Knowing which surgeries are considered low, intermediate and high risk	0.52
Ability to Identify appropriate work-up for low risk surgical candidates*	0.82
Ability to identify appropriate work-up for high risk surgical candidate*	0.63
Critical Care management	
knowing the pathophysiology of cardiogenic shock	0.33
comfort with the management of cardiogenic shock	0.48
knowing the different types of mechanical assist devices used to treat cardiogenic shock	0.34
knowing the hemodynamics of cardiogenic shock	0.48
Knowing when to refer patients for invasive hemodynamic monitoring (RHC)	0.79
Confidence in recognition of normal hemodynamic tracings	0.48
Ability to identify the most appropriate management of cardiogenic shock*	0.26
Ability to correlate a hemodynamic profile with the correct type of shock*	0.12
Ability to identify the p/f ratio indicative of severe ARDS*	0.56
Ability to identify the most appropriate management for septic shock *	0.48
PAD	
comfort with managing PAD	0.76
Confidence in differentiating chronic from acute limb ischemia	0.46
familiarity with the risk factors for PAD	0.24
Knowing how to measure an ABI	0.52
Ability to identify the normal ABI range *	0
Valvular Disease	

Comfort with the anatomy of the mitral valve	0.4
Comfort with the medical management of MR	0.64
Comfort identifying a MS murmur	0.37
Knowing the causes of mitral stenosis	0.36
Comfort with the management of MS	0.34
comfort with the management of AI	0.21
Ability to identify the correct description of an AS murmur*	0.23
Ability to identify the AVA for severe AS*	0.49
Congenital Heart Disease: ASDs	
Comfort quantifying a cardiac shunt using the Qp/Qs equation	0.6
Knowing the different types of ASDs	0.58
Ability to identify the EKG finding commonly associated with an ASD*	0.49
Ability to identify cardiac defects frequently seen with ASDs*	0.34
Ability to identify structural abnormalities associated with longstanding ASDs*	0.13
Ability to correctly identify a hemodynamically significant Qp:Qs ratio*	0.23
Heart Failure	
Comprehension of HF pathophysiology	0.39
Comfort with interpretation of the HF exam	0.38
Knowing GDMT for HF	0.27
Comfort performing a H&P on a HF patient	0.15
Ability to identify GDMT*	0.02
Echo	
Comfort identifying standard echocardiography views	0.13
Demonstrating an understanding of the continuity equation *	0.11
Ability to calculate AVA based on echo parameters*	0.54
Miscellaneous	
Knowing the differential diagnosis for syncope	0.4
Knowing the work-up for syncope	0.39
Ability to identify COVID-19 cardiac complications*	0.24
Ability to correctly identify a common provocation of vasovagal syncope*	0.19
Pharmacology	
Ability to identify the mechanism by which Digoxin decreases HR*	0.37
Ability to identify the mechanism of action of Nipride *	0.57
Ability to identify how dopamine is cleared*	0.73
Ability to identify appropriate dopamine dosing for cardiogenic shock*	0.19

Ability to identify the mechanism of action of milrinone *	**0.16**
Ability to identify the mechanism of action of Dobutamine*	**0.26**

Sample Subjective Assessment Question with Associated Answer choices:

1. I know when to refer a patient with mitral stenosis for corrective intervention
    A. Strongly Agree
    B. Agree
    C. Neither agree nor Disagree
    D. Disagree
    E. Strongly Disagree

Sample Objective Assessment Question with Associated Answer choices:

2. What echocardiography finding would you expect to see with a longstanding ASD?
    A. Hypertrophied RV
    B. Dilated LV
    C. Hypertrophied LV
    D. Dilated RV

Appendix Table 2

Objective Assessments Associated with small effect sizes <0.3	Percent of trainees who answered objective questions correctly pre-intervention	Percent of trainees who answered objective questions correctly post-intervention	Presence of the Ceiling Effect	Fluency of the lecturers
Correctly identifying a common cause of vasovagal syncope	30%	50%	No	Multilingual
Correctly identifying COVID-19 cardiac complications	86%	100%	Yes	English, Monolingual
Correctly identifying the mechanism of action of Dobutamine	63%	88%	No	English, Monolingual
Correctly identifying the characteristics of an aortic stenosis murmur	86%	100%	Yes	English, Monolingual
Correctly identifying a normal ankle brachial index range	100%	100%	Yes	Multilingual
Correctly identifying the mechanism of action of Milrinone	57%	75%	No	Multilingual
Correctly identifying cardiogenic shock based on hemodynamic profile	57%	71%	No	Multilingual
Correctly identifying the most appropriate management of cardiogenic shock based on clinical presentation	29%	54%	No	English, Monolingual
Correctly identifying structural abnormalities associated with a longstanding atrial septal defect	70%	83%	No	English, Monolingual

Correctly identifying a hemodynamically significant Qp:Qs ratio*	60%	33%	No	English, Monolingual
Correctly identifying all heart failure guideline directed medical therapies*	77%	75%	No	English, Monolingual
Correctly dosing Dopamine for cardiogenic shock *	71%	50%	No	English, Monolingual
Correctly identifying the definition of the continuity equation *	83%	71%	No	English, Monolingual
Subjective Confidence assessments associated with small effect sizes <0.3	Percent of trainees who were either comfortable or very comfortable on the rating scales pre-intervention	Percent of trainees who were either comfortable or very comfortable on the rating scales post-intervention	Presence of the Ceiling Effect	Fluency of the Lectures
Comfort with guideline directed medical therapy for heart failure	100%	100%	Yes	English, Monolingual
Comfort with performing a heart failure history and physical exam	100%	100%	Yes	English, Monolingual
Comfort with identifying standard echo views	100%	100%	Yes	English, Monolingual
Comfort identifying risk factors for peripheral arterial disease	83.30%	100%	Yes	Multilingual
Comfort managing aortic insufficiency	50%	85.70%	No	English, Monolingual

*Negative small effect sizes