Impact of the COVID-19 pandemic on interventional cardiology training in the United States

Samit Shah MD, PhD1 | Yulanka Castro-Dominguez MD1 | Tanush Gupta MD2 | Robert Attaran MD, FSCAI1,3 | Graham Vance Byrum III MD4 | Adam Taleb MD5 | Amanda Pettyjohn BA3 | Robert C Bartel MS3 | Molly Szerlip MD, FSCAI3,6 | Timothy D. Henry MD MSCAI3,7 | Ehtisham Mahmud MD, FSCAI5,3 | Robert J Applegate MD, MSCAI4,3

1Section of Cardiovascular Medicine, Yale School of Medicine, New Haven, Connecticut
2Division of Cardiology, Columbia University Medical Center, New York, New York
3Society for Cardiovascular Angiography and Intervention, Washington, District of Columbia
4Section of Cardiovascular Medicine, Wake Forest University School of Medicine, North Carolina
5Division of Cardiovascular Medicine, UC San Diego, California
6Division of Cardiology, Baylor Scott and White, Plano, Texas
7The Carl and Edyth Lindner Center for Research and Education, The Christ Hospital, Cincinnati, Ohio

Correspondence
Robert J Applegate, MD, Section of Cardiovascular Medicine, Wake Forest School of Medicine, 1 Medical Center Drive, Winston Salem, NC 27157.
Email: bapplega@wakehealth.edu

Abstract

Objectives: We sought to determine the effect of COVID-19 related reduction in elective cardiac procedures and acute coronary syndrome presentations on interventional cardiology (IC) training.

Background: The COVID-19 pandemic has significantly disrupted healthcare in the United States, including cardiovascular services. The impact of COVID-19 on IC fellow training in the United States has not been assessed.

Methods: The Society for Cardiovascular Angiography and Interventions (SCAI) surveyed IC fellows training in both accredited and advanced non-accredited programs, as well as their program directors (PD).

Results: Responses were received from 135 IC fellows and 152 PD. All respondents noted reductions in procedural volumes beginning in March 2020. At that time, only 43% of IC fellows had performed >250 PCI. If restrictions were lifted by May 15, 2020 78% of IC fellows believed they would perform >250 PCI, but fell to only 70% if restrictions persisted until the end of the academic year. 49% of IC fellows felt that their procedural competency was impaired by COVID-19, while 97% of PD believed that IC fellows would be procedurally competent at the end of their training. Most IC fellows (65%) noted increased stress at work and at home, and many felt that job searches and/or existing offers were adversely affected by the pandemic.

Conclusion: The COVID-19 pandemic has substantially affected IC training in the United States, with many fellows at risk of not satisfying current program procedural requirements. These observations support a move to review current IC program requirements and develop mitigation strategies to supplement gaps in education related to reduced procedural volume.

Keywords: competency, coronavirus, interventional cardiology, medical education, procedure volume, training
1 | INTRODUCTION

The international outbreak of novel coronavirus (SARS-CoV2) infection and the associated coronavirus-related respiratory disease, referred to as COVID-19, has drastically impacted healthcare in the United States. Efforts to limit exposure to healthcare workers and uninfected patients, preserve personal protective equipment (PPE), and reduce hospital resource utilization led the Centers for Medicare & Medicaid Services (CMS) to issue a statement on March 18th, 2019 recommending that “all elective surgeries, non-essential medical, surgical, and dental procedures” be delayed during the COVID-19 crisis. As a result, healthcare organizations throughout the United States prioritized urgent or emergent care for patients with COVID-19 and canceled or postponed elective cardiovascular procedures. This dramatically affected procedural volumes in cardiac catheterization laboratories throughout the country. Furthermore, during this same period, hospitals around the country experienced a 38% reduction in catheterization laboratory activation for suspected ST-segment elevation myocardial infarction (STEMI). The combined effect of the deferral of elective cardiovascular procedures and reduced presentations for STEMI has likely significantly affected the training of interventional cardiologists, which depends on clinical and procedural volume, but the impact of this has not yet been well studied.

As with other procedural fields, developing an adequate technical skill set and knowledge base in interventional cardiology (IC) depends on sufficient training experience. IC fellowship programs are generally 12 months in duration and focus on developing expertise with acute coronary syndromes and percutaneous coronary intervention (PCI), in addition to the management of cardiogenic shock, valvular heart disease, cardiac tamponade, and vascular complications. The Accreditation Council for Graduate Medical Education (ACGME) common program requirements for one-year fellowships mandate the development of sufficient medical knowledge as well as a minimum volume of 250 PCI. Most training programs include basic experience in structural heart disease (SHD), complex and higher-risk coronary intervention (CHIP), and peripheral vascular intervention (PVI), but many fellows choose to pursue additional advanced sub-specialty training in these fields. While standardized case volume requirements do not exist for advanced training programs, there is evidence that more experience may lead to better outcomes. Subspecialty board certification of interventional cardiologists with the American Board of Internal Medicine (ABIM) requires that board eligible candidates have completed 250 “therapeutic cardiovascular interventions,” which may include endovascular or structural interventions. This creates two separate volume-based proficiency requirements for IC fellows, and a reduction in case volume could affect both procedural competency and candidacy for board certification.

To better understand the effect of the COVID-19 pandemic on IC trainees in the United States, the Society for Cardiovascular Angiography and Interventions (SCAI) formed a “Training Standards COVID-19 Task Force” with participation from interventional cardiologists and IC fellows from around the United States. Comprehensive surveys were disseminated to trainees in IC, structural, CHIP, and PVI programs as well as the program directors (PD) of these programs. We sought to describe the effect of COVID-19 on the training experience, procedural volume/competency, and employment prospects for fellows. We also evaluated the impact of the pandemic on the certification of graduating fellows within the volume-based proficiency frameworks of the ACGME and ABIM.

2 | MATERIAL AND METHODS

2.1 | Survey

We designed questionnaires with 65 items (fellows) and 40 items (PD) which explored the following categories: (a) baseline characteristics; (b) changes in clinical activities; (c) procedural volume; (d) extent of training; (e) social and personal impact; (f) professional activities and employment (supplemental figures). We used internet-based software (SurveyGizmo, Boulder, CO) as the platform for the survey. To ensure that surveys were understandable each survey was reviewed by fellow and program director participants of the Task Force. The survey was launched on April 28th, 2020 and closed on May 18th, 2020. The survey was disseminated to IC fellows by email through mailing lists compiled by SCAI based on registration for fellows’ courses, as well as through social media, and to PD using a SCAI membership database. Survey responses were anonymous and no identifying information was solicited. This study was reviewed by the Yale University Institutional Review Board and deemed exempt from formal review.

2.2 | Data analysis

Descriptive data were obtained from survey responses. Data are presented as total number of responses and percentages of total respondents. Statistical analysis was performed using two-sided chi-square tests for categorical variables using the SPSS software (IBM SPSS; Armonk NY).

3 | RESULTS

3.1 | Fellows

Of the 220 fellows who were contacted, 135 responded (61%). Most respondents identified as IC fellows (88%) and the remainder identified as structural (3), CHIP (3) or peripheral vascular (4). The majority of fellows were male (79%) and within the age range of 25–34 years (62%). Most (56%) were from programs with 3–5 fellows, while 38% were from programs with 1–2 fellows and 7% from larger programs with >6 fellows. Fellows who responded represented 29 states, the majority were from the Northeast region (58%, Figure 1a). Programs were based in cities with populations of <100,000 (12%), 100,000–500,000 (29%), 500,000–1 million (24%), and >1 million
people (35%) (Figure 1b). Most fellows were training in academic, university-based medical centers (90%) as well as some representation by government/veterans’ affairs medical facilities (14%), and private, community-based institutions (17%).

3.2 | Program directors

Of the 164 accredited IC program directors, 152 PD responded (93%). Most respondents identified as PD of ACGME accredited IC training programs (91%) and the remainder identified as PD of structural (16), CHIP (9), or peripheral vascular (9) programs. Responding PD directed programs with 1–2 fellows (58%), 3–5 fellows (38%), and > 6 fellows (4%). PD who responded represented 29 states and programs were based in cities with populations of <100,000 (13%), 100,000–500,000 (20%), 500,000–1 million (27%), and > 1 million people (40%).

3.3 | Impact on procedural volume

We assessed the baseline reported procedural volume of the ACGME IC fellows (n = 78) prior to the COVID-19 pandemic. For the academic year prior to COVID-19 (July 2018–July 2019), 98% of PD reported that their fellows performed more than 250 PCI. However, for the current academic year (July 2019–July 2020) only 70% of PD believes that fellows will complete 250 PCI, and 87% believe that fellows will complete 250 total cardiovascular interventions (including structural and peripheral interventions). All fellows and PD reported a reduction in procedural volume as a result of the COVID-19 pandemic. As of March 1, 43% fellows had performed more than 250 PCI, and 78% believed they could complete 250 PCI if COVID-19 related restrictions were lifted by May 15th (Figure 2). If restrictions remained in place, 30% reported that they would not reach 250 PCI. Fellows from larger cities (>500,000 people) were more likely to report they anticipated performing fewer than 250 PCI if the COVID-19 related restrictions remained in place, compared with fellows from smaller cities (<500,000 people) (39% vs. 16%, p = .029; Table 1). However, fellows from larger cities were also more likely to report having less than 250 PCI by March 1st compared with fellows from smaller cities (61% vs. 47%, p = .026). We further examined the association between PCI volume and gender, fellow age, geographic region of the fellowship program, program size, fellow redeployment status, and fellow perceptions of competency and found no significant relationships (Table 2). For most fellow and program director respondents, catheterization laboratories halted elective cases in March 2020 (96%). After these changes went into effect, 42% of fellows reported increased competition for cases but this was only reported by 22% of PD.

3.4 | Impact on interventional fellow activities (n = 86)

As a result of COVID-19 associated changes to healthcare operations, most fellows (80%) reported working fewer hours with 12% reporting no change and 8% reporting increased work hours. PD reported similar changes to work hours, with 74% reporting that fellows worked fewer hours. Most PD reported having formal discussions with fellows regarding the changes to training as a result of the pandemic (67%), while 56% of fellows reported having formal discussions but 17% of fellows reported discussions that did not include solutions for concerns.

Fellows requiring a period of quarantine due to confirmed or suspected COVID-19 was uncommon (13%), although an additional
15% were quarantined due to family exposures or as a precautionary measure. A moderate number of fellows (28%) of fellows were required to provide clinical care outside of typical clinical responsibilities, serving as attending cardiologists (4), intensive care unit providers (19), or providing medical floor coverage (11), and as general cardiology fellows (1) (Figure 3). Of the 16 fellows who relied on moonlighting for supplemental income, 43% experienced a reduction in supplemental income as a result of COVID-19.

As a result of the pandemic, most fellows experienced a change to the care of patients with STEMI, including the administration of tissue plasminogen activator (tPA) for thrombolysis (12%), cohorting of patients to one laboratory (64%), and mandated use of full personal protective equipment (PPE) (72%). Some fellows reported increased participation in the initiation of veno-veno and veno-arterial extracorporeal membrane oxygenation (ECMO) (10%), while others reported only a change in ECMO protocols (13%), or no significant change in ECMO training (74%).

### 3.5 Extent and quality of training

Of the fellows who responded, 47% felt that COVID-19 related changes to fellowship training would reduce their procedural competency (Figure 4). However, 97% of PD felt that fellows would be prepared to be independent cardiovascular operators by the end of training. Some fellows (18%) showed interest in extending training to achieve an adequate case volume, the majority (78%) indicating that 1–2 months would be the most appropriate duration. In contrast, only 12% of PD were in favor of extending training. Most PD (75%) did not anticipate making changes to the program curriculum for incoming fellows who started on July 1st, 2020. When asked regarding the requirement for 250 cardiovascular interventions prior to sitting for the ABIM Interventional Cardiology certification exam, 21% of fellows believed that they may not reach that requirement due to the COVID-19 pandemic (Figure 5a). However, the majority of fellows (93%) did not...
TABLE 2  Number of fellows anticipating >250 PCI by the end of training

|                              | <250 PCI (n = 22) | >250 PCI (n = 54) | p-value |
|------------------------------|-------------------|-------------------|---------|
| **Gender**                   |                   |                   | .973    |
| Male                         | 18 (29%)          | 44 (71%)          |         |
| Female                       | 4 (29%)           | 10 (71%)          |         |
| **Age**                      |                   |                   | .153    |
| 25–34 years                  | 10 (22%)          | 36 (78%)          |         |
| 35–44 years                  | 12 (41%)          | 17 (59%)          |         |
| 45–54 years                  | 0                 | 1                 |         |
| **Geographic region**        |                   |                   | .664    |
| Northeast                    | 13 (32%)          | 28 (68%)          |         |
| Midwest                      | 3 (21%)           | 11 (79%)          |         |
| South                        | 3 (21%)           | 11 (79%)          |         |
| West                         | 3 (43%)           | 4 (57%)           |         |
| **Size of program**          |                   |                   | .859    |
| 1–2 fellows                  | 8 (27%)           | 21 (72%)          |         |
| 3–5 fellows                  | 13 (31%)          | 29 (69%)          |         |
| >6 fellows                   | 1 (20%)           | 4 (80%)           |         |
| **Redeployment to non-IC role** |                 |                   | .742    |
| Yes                          | 5 (25%)           | 15 (75%)          |         |
| No                           | 17 (30%)          | 39 (70%)          |         |
| **Perception of competency** |                   |                   | .336    |
| Less competent               | 13 (35%)          | 24 (65%)          |         |
| No change in competency      | 9 (25%)           | 27 (75%)          |         |

Note: Projected PCI volume reported by fellows if pandemic-related restrictions remain in place until the end of training, as stratified by gender, age, geographic region, size of program, re-deployment to non-IC roles, and whether fellows believed the pandemic would affect procedural competency. A total of 22 fellows (29%) reported that they would not reach 250 PCI by the end of training if Covid-19 pandemic related restrictions remained in place while 54 fellows (71%) reported that they would complete >250 PCI. Stratified by gender, 29% of both men and women reported that they would not achieve 250 PCI with no significant association between gender and PCI volume (p = .973). There was no significant association between age (p = .153), geographic region (p = .664), size of program (p = .859), redeployment status (p = .742), and fellowsʼ perception of the impact of the pandemic on competency (p = .336).

FIGURE 3  Fellow redeployment duties during pandemic (n = 24). A total of 24 fellows reported being redeployed as a result of COVID-19 pandemic related changes in healthcare operations. Fellows were most likely to be redeployed to the work in an intensive care unit (79%) setting or medical floor (46%), with some fellows being asked to serve as cardiology attendings (17%).
believe that the COVID-19 pandemic would affect their ability to pass the certification exam (Figure 5b).

3.6 | Personal impact of COVID-19 pandemic

Most fellows (65%) reported significant personal or home-life stress as a result of the COVID-19 pandemic, and 80% reported having appropriate support to help cope with the increased stress. Regarding specific stressors, fellows reported changes in living situations or temporary housing (15%), increased stress with spouse/family (55%), challenges with childcare (27%), personal illness (5%), and family member illness (10%). Respondents provided text responses to describe not being able to visit family, being quarantined abroad due to visa restrictions and not being able to return to the home training program, and challenges in dual provider households.

3.7 | Effect on professional activities and employment

The majority of fellows (78%) reported that as of March 1st they had found employment or a position for subsequent training following their current training program. Specifically, 26% will join the faculty of an academic institution, 40% will join a private practice, and 35% will continue training (22% at the same institution and 13% at a different institution). Of the fellows who had found positions, 26% were unable to travel for a subsequent interview, credentialing, or to find housing; 6% were impacted by a hiring freeze at a prospective employer, and 17% will have a delay in the start date. Fellows who had not yet found positions described challenges due to not being able to travel for job interviews (50%), hiring freezes at potential employers (60%), fewer positions available (60%), and delayed starting dates (50%). PD reported that 24% of fellows had described challenges finding employment.

3.8 | Solutions to enhance education and training

To mitigate the effects of the COVID-19 pandemic on training, fellows reported that they are participating in live/recorded case reviews (59%), reading textbooks/journals (70%), film review at their local institution (71%), and simulation training (3%). Fellows in New England reported the development of a regional, multi-center consortium for didactics and case reviews. Most fellows (91%) are interested in further educational activities and indicated that the most beneficial would be broadcast live/recorded cases (80%), interactive virtual case review (81%), fellow’s film review with faculty discussants (74%), and virtual journal club (42%). Many fellows had to cancel attendance (62%) or presentations (24%) at a professional meeting, and only 43% of fellows reported involvement in COVID-19 related research or educational activities. In contrast, 60% of PD believed fellows were participating in COVID-19 related research or educational activities.

4 | DISCUSSION

The COVID-19 pandemic has had an unprecedented impact on healthcare systems and medical education. From the period of March until May of this year, hospitals reduced cardiovascular procedure volume, which had the adverse side effect of reducing the case volume of trainees in IC. To assess the impact of the pandemic on IC training SCAI surveyed fellows and PD in the United States to determine the impact on (a) procedural volume; (b) clinical activities; (c) extent and quality of training; (d) personal life; and (e) professional activities and employment. Our primary findings are that a significant proportion of fellows perceive that by the end of training they may not reach minimum procedure requirements set by the ACGME (250 PCI) and ABIM (250 cardiovascular interventions); and nearly half believe that the pandemic will affect their procedural competency. Interestingly, and despite the apprehension noted by the IC fellows of the impact of COVID-19 on their training, 97% of PD believed that, regardless of the pandemic, their fellows would be ready for independent practice by the end of the academic year. This discrepancy in perceived competency between fellows and program directors is notable and may
reflect the baseline uncertainty that many new graduates feel when entering independent practice and the effect of reduced case volume during the pandemic. The external perception from program directors is that, despite having a reduced case volume, these fellows will be adequately prepared for their careers. Thus, our results provide important data regarding the impact of the COVID-19 pandemic effect on Interventional Cardiology training and suggest that simple volume-based competency standards need to be re-evaluated.

Other smaller studies have also demonstrated an effect of the COVID-19 pandemic on regional IC training. A recent survey of the IC programs in the New York City metropolitan area (25 fellows in 14 programs) reported that >95% of respondents felt that the pandemic had a moderate or severe impact on their training and only ~50% felt confident to be able to achieve the required level of technical competence by the end of their training.11 Importantly, roughly one-third of the PD and fellows who participated in that survey felt that there should be either an extension of training or a period of on-the-job mentorship to supplement the loss of procedural training time due to the COVID-19 pandemic. Our results expand on the efforts from the New York programs by including fellows and PD from the entire country and providing a more detailed assessment of the impact of the pandemic on fellows. Similar pandemic related effects on training likely have occurred across the spectrum of medical education.

Nearly one third of fellows in ACGME accredited IC programs perceived that they may not reach 250 PCI during their training year if procedural restrictions remain in place until the end of the year. Furthermore, 21% of fellows did not believe that they could reach the requirement of 250 cardiovascular interventions required by the ABIM prior to sitting for the IC certification examination. There was a significant association with the size of the city of each program and PCI volume, in that fellows from larger cities (>500,000 people) anticipated more challenges completing 250 PCI by the end of the year than fellows from cities with less than 500,000 people. However, fellows in programs from larger cities had a lower procedural volume at baseline, which may be related to more competition for cases among multiple health systems. Notably, there was no association between program size (in number of fellows) and PCI volume.

How important is reaching 250 PCI or 250 cardiovascular interventions? The original clinical competency consensus statement for “Clinical Competence in Percutaneous Transluminal Coronary Angioplasty” recommended a minimum of 125 coronary angioplasty procedures during a formal one-year advanced training program.9 Since that time, the volume requirement has increased and the current benchmarks based on the “judgment” of “experienced interventional cardiovascular experts” rather than data.10 In addition to procedure volume an equally important facet of training is cognitive development and fund of knowledge. These “soft” metrics are more difficult to quantify than the number of interventions, but in an era where PCI volume may be decreasing regardless of a pandemic, cognitive skills are of increasing importance. In our study, PD attested to the competency of graduating fellows independent of PCI volume. While this may reflect optimism of PD regarding their own fellows and an effort to maintain program accreditation, 97% of the surveyed PD felt that their graduates would be ready for independent practice, suggesting that perceived competency is more complex than “just” PCI volume. The ACGME, which administers and accredits training programs, has a volume requirement that all IC fellows perform 250 PCIs to maintain satisfactory program requirements. In contrast, the ABIM, which administers and provides IC fellow board certification, requires that IC

![Figure 5](https://example.com/figure5.png)

**FIGURE 5** Fellow reported ability to reach 250 Cardiovascular Interventions and Confidence Regarding Interventional Cardiology Board Certification. The majority of fellows (79%) reported that they would reach 250 cardiovascular interventions by the end of training despite restrictions related to the COVID-19 pandemic, but 21% did not believe they could achieve that number of interventions (a). Despite this, only 3% of fellows believed that the pandemic would affect their ability to achieve a passing score on the ABIM Interventional Cardiology certification exam (b). [Color figure can be viewed at wileyonlinelibrary.com]
fellows perform 250 overall cardiovascular therapeutic interventions to sit for the IC certification exams. This dichotomy may be relevant in this COVID era where IC fellows may end up sitting for board certification, but programs may not meet ACGME requirements. For example, a fellow or recent graduate from an ACGME accredited IC program may fulfill the ABIM requirement with peripheral and structural interventions during fellowship or early practice without satisfying the 250 PCI requirement mandated by the ACGME. These scenarios underscore the importance of having a single standard to achieve, which should recognize both the volume and cognitive skills of IC fellows.

Our survey found that not only did the COVID-19 pandemic affect fellow training, but also broadly increased stress in their personal lives. The responding fellows have experienced personal and professional hardships, with 65% reporting significant home-life stress. In particular, fellows noted increased stress with their families, and more than a quarter of respondents have had challenges with childcare. Regarding employment after fellowship, 78% of respondents had accepted a position following the current training year. Of the fellows who had not yet found positions many noted that they were unable to travel for interviews, affected by hiring freezes/delayed start dates at potential employers, and believe that fewer positions are available. While many of these concerns are related to the healthcare economics of this pandemic, the inability to find employment is major source of stress to graduates in the final months of a long training pathway. The COVID-19 pandemic has had an unprecedented impact on healthcare delivery and medical education. Regarding the training of IC fellows, the interruption in procedural volume has given our field an opportunity for re-evaluating historical methods of evaluating competency. Based on our findings future directions should include creating a framework for adapting IC education to potential interruptions in cardiovascular procedure volume (i.e., natural disasters, personal circumstances, changes to hospital operations), open discussions regarding methods for determining/documenting competency, and the development of widely-available educational programs that can supplement learning that occurs in the catheterization laboratory.

5 | STUDY LIMITATIONS

This study has several limitations, which may affect the generalizability of our observations. We polled IC fellows who attended the SCAI Fall Fellows meeting, which was attended by approximately one-half of all United States IC fellows. Thus, it is possible there may be a sampling bias among the IC fellows responding. However, we received responses from IC fellows all over the country, and from both small and large programs so this potential bias is unlikely to have substantially skewed our results.

We did not have a comparator group responding to our questionnaire (i.e., IC fellows who did not experience a COVID-19 effect on their training) so it is hard to definitively assign responsibility to COVID-19 versus inherent concerns of the extent and quality of their training. Additionally, we surveyed current fellows who had not yet graduated at the time of our survey, so the impact of the pandemic on future practice was based on fellows’ subjective concerns. The actual impact of the pandemic on training with regard to future independent practice remains unknown.

6 | CONCLUSIONS

The COVID-19 pandemic has substantially affected IC training in the United States, with many fellows at risk of not satisfying current program procedural requirements. These observations support the need to review current IC program requirements, including both procedural and cognitive skills, and develop mitigation strategies to supplement gaps in education related to reduced procedural volume.

CONFLICT OF INTEREST

Dr Szerlip is a consultant and speaker for Edwards Life Sciences, Medtronic, Abbott, and Boston Scientific. Dr Mahmud reports clinical research support from Cardiovascular Systems Inc., Corindus, and Abbott Vascular, and is a consultant for Medtronic and Abiomed. None of the remaining authors have anything to disclose.

ORCID

Samit Shah https://orcid.org/0000-0002-3664-4102
Tanush Gupta https://orcid.org/0000-0002-2047-2625
Molly Szerlip https://orcid.org/0000-0002-4907-1825
Timothy D. Henry https://orcid.org/0000-0003-1123-0533

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