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Training and Career Development in Cardio-Oncology Translational and Implementation Science



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KEYWORDS

• Cardio-oncology • Trainees • Education • Cardiology • Oncology

KEY POINTS

- The necessity of training in cardio-oncology increases as the number of cancer survivors with cardiovascular complications increases.
- Many variables need to be considered when establishing a cardio-oncology program.
- With the increase of social media, there are multiple new formats and avenues for training and career development.

INTRODUCTION

The cancer population continues to increase with approximately 1.9 million new cases projected for 2021¹ and more than 20 million cancer survivors projected to be alive in the United States by the next decade.² In response, the multidisciplinary field of cardio-oncology has emerged rapidly in order to provide clinical care and research initiatives to address the cardiovascular care of this unique and vulnerable population. This field within cardiology is unique due to the necessity of harmonizing care between 2 major fields within Medicine, in addition to the dynamic

demands of addressing the numerous and heterogeneous treatment strategies of the different kinds of cancer. Finally, a current and ongoing challenge is trying to understand, detect, and treat the cardiotoxicities that may accompany both historical agents and the deluge of novel therapeutics that are being developed at an unprecedented pace.

With the successful establishment of cardio-oncology as a major subspecialty within the fields of cardiology and oncology, a fundamental objective is to define an effective strategy of training and providing education to scientists and health care professionals (eg, physicians, nurse practitioners,

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pharmacists, and others) who wish to pursue research endeavors in and achieve clinical competence in the field, respectively. Such efforts, if successful, will allow for cardio-oncology to develop a sustainable model of education and research that will lead to growth of the field on a wide scale. Such desired objectives would include (1) structured, standardized training curricula for research and clinical trainees in cardiology and hematology/oncology programs; (2) establishment of private and public sector-funded research programs that can provide not only a platform for scientific discovery and advancement but also cyclical funding for both training and research programs; and (3) the development of competent, knowledgeable health care workers who are able to provide high-quality clinical care to the cardio-oncology population within a variety of health care systems, with the ability to continue lifelong self-learning with the dynamic nature of the field. All of this occurs best in the context of established comprehensive cardio-oncology programs or centers of excellence.

In this report, the authors provide an overview of optimal infrastructure for training and career development in cardio-oncology translational and implementation science (Fig. 1). They lay the foundation for building cardio-oncology programs with emphasis on collaborations among clinicians and scientists. The authors also highlight the role of the multidisciplinary cardiovascular team for both research and patient care. Opportunities for cardio-oncology training in general cardiology fellowship, hematology/oncology fellowship, dedicated cardio-oncology clinical fellowship with research, and cardio-oncology research fellowship are described, with proposed training for the multidisciplinary cardiovascular team (Fig. 2).

INFRASTRUCTURE FOR TRAINING *Cardio-Oncology Program*

Although the cardio-oncology literature has several reviews on strategies to establish a cardio-oncology program,^{3–9} each institution has its unique challenges based on varying degrees of institutional, faculty, financial, and logistical support. In addition to this, cardio-oncology is unique in that it is a field that depends on another subspecialty of Medicine—for multidisciplinary collaboration and the referral of its unique cancer patient population. Advocates who are invested in starting and/or building a cardio-oncology program at their own institution need to begin identifying gaps in support and champions both within cardiology and oncology divisions to promote this multidisciplinary collaboration. Identifying cardiovascular needs within an institution's oncology population and generating services lines for clinical referrals based on these needs may be an initial effective strategy for program building and the subsequent integration of didactics and training of house-staff into their curriculum to help garner support in the realms of clinical care and research. Depending on programmatic funding, whether it is based on clinical revenue and/or research funding, such financial sources of support also need to be identified and prioritized in order to develop the building blocks necessary for an effective training program.

In order for an effective training program to exist, whether its focus is on clinical care, research, or both, it can be argued that a robust cardio-oncology program needs to be a prerequisite in order to expose the trainee to the diverse spectrum of malignancies and related cardiotoxicities. Analogously, it would be presumed that in order for an effective training program in structural

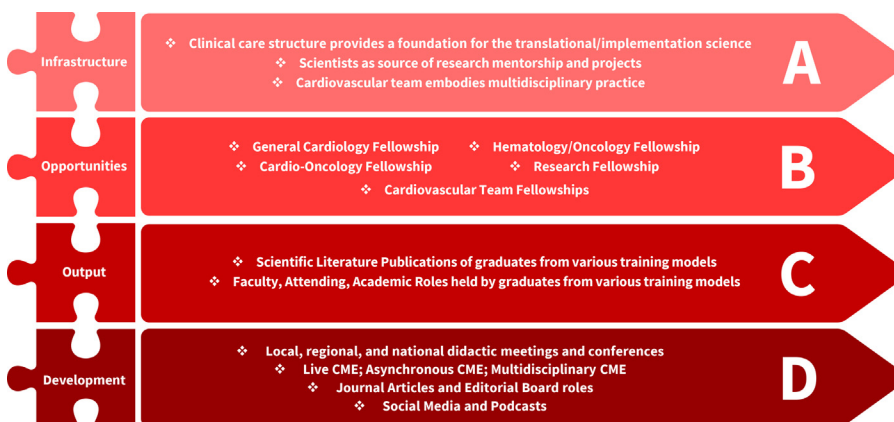


Fig. 1. Components of training and career development in cardio-oncology translational and implementation science.

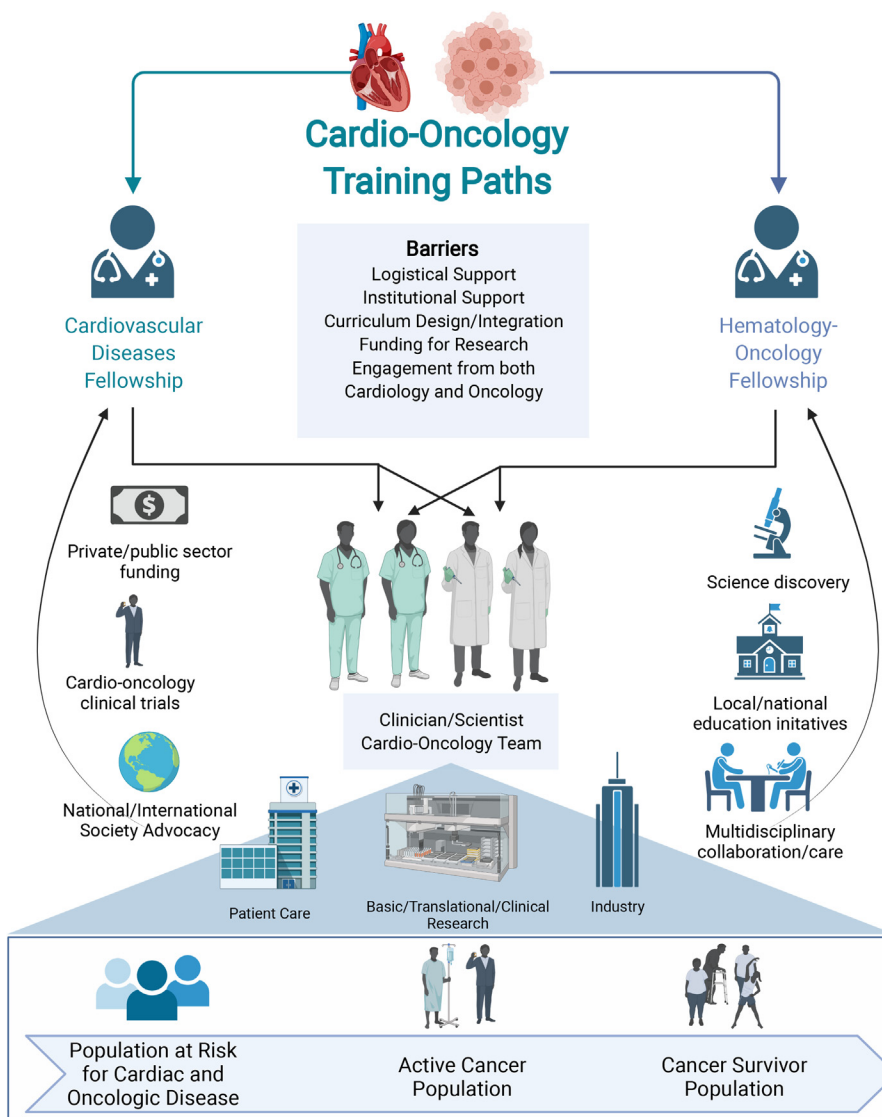


Fig. 2. Cardio-oncology training paths for physician scientists. (Created with BioRender.com.)

cardiovascular interventions and imaging to be successful, there would need to be preexisting high-volume cardiac catheterization laboratory with cardiothoracic surgery, advanced imaging capacity, and a heart team approach to these cases. Already, many health care centers with cardiology fellowships have begun these efforts; a survey conducted in 2017 revealed that approximately 51% of those who responded (n = 81) were part of institutions spread across the United States that provided dedicated cardio-oncology services, and almost a half of those responders were providing cardio-oncology-related didactics. At the time of the survey, programs had dedicated training opportunities specific to cardio-oncology, ranging from clinical observerships to training

programs ranging from less than 6 months to at least a year.¹⁰ In addition, in the same format as the American College of Cardiology (ACC) Core Cardiovascular Training Symposium (COCATS) training (the standardized training documents to achieve competency in Cardiovascular training), the ACC Cardio-Oncology Section Council also devised a proposed curriculum that would allow for training at 3 levels of competency, depending on the extent of immersion that a trainee would strive to aim for during their general fellowship training.¹¹ However, it is also acknowledged that cancer-related clinical services can be highly variable and heterogeneous in health care systems across the country, and it is possible that not all programs will have the same degree of exposure

to all cancer states and drug classes that can cause cardiotoxicity.

Cardio-Oncology Research

Care of patients in cardio-oncology programs is driven by expert recommendations and scientific statements.^{12–18} More guidelines are becoming available, in large part due to the growing breadth of research conducted in cardio-oncology. This research is pursued by scientists in collaboration with clinicians and oftentimes by physician scientists. A fundamental objective of cardio-oncology training is therefore the production of physician scientists, whether focused on basic science, translational, clinical, or population health research. The International Cardio-Oncology Society (ICOS) and Canadian Cardiac Oncology Network (CCON) training statement highlighted the importance of translational research in understanding cardiotoxicity, as a thorough understanding of the underlying biological pathways can inform screening and treatment.¹⁹ Similarly, clinical and population health research is necessary in an iterative manner, given the dynamic nature of cancer treatment.

In programs with established cardio-oncology faculty, the major question is finding a project that aligns with the career goals of the trainee. For those in general cardiology training or a clinically based cardio-oncology program, a dedicated clinical or population health study with preexisting data may be more manageable than a more time-intensive basic science or translational study. Identification of mentorship at sites without dedicated cardio-oncology faculty can be challenging. There may not be researchers within oncology that focus on cardiovascular aspects of cancer treatment. Likewise, not all centers will have cardiologists with a particular interest in the cancer population, and this can be overcome by identifying an established mentor in cardiology or oncology and focusing on cardio-oncology-specific questions within their existing research infrastructure; this may ultimately be advantageous by creating a niche for the trainee in that working group.

Within the limited training time horizon of either 1 or 2 years for most cardio-oncology training programs, there needs to be a finite defined period for research, as the balance between producing a well-rounded clinician and importance for research has to be considered. Hence, early identification of a mentor is crucial.

Although the field is rapidly advancing, there remain many areas in need of further study and gaps in knowledge.

Some of these examples include the following:

- Better understanding of mechanistic pathways of cardiotoxicity from targeted therapies including the different classes of tyrosine kinase inhibitors.
- Improved understanding of long-term cardiovascular risk in adult cancer survivors. Although long-term follow-up exists in childhood cancer survivors via the St. Jude Childhood Cancer Survivor Study,²⁰ a similar longitudinal registry remains lacking in adults.
- Holistic and long-term impact of immunotherapy on cardiovascular health. Although early studies identified risk for immune-checkpoint-associated myocarditis²¹ and more recent work has noted increased risk for atherosclerosis,²² the effects of immune checkpoint inhibitors on the cardiovascular system remain incompletely understood.
- The concept of cardio-immuno-oncology, including immune checkpoint inhibitors, chimeric antigen receptor T cells, and bispecific T-cell engagers.²³ Long-term implications of the increasing use of cancer therapies modulating the immune system, leading to sustained negative changes to the cardiovascular system related to cytokine release, systemic inflammation, and other bidirectional mechanisms. This is a rapidly changing field in which data regarding cardiotoxicities and drug development for immunotherapy evolve quickly. Thus, a robust training and research environment for cardio-oncology is needed to address this growing armamentarium.

Access to these types of data is not typically available and requires close collaboration between cardiology and oncology teams at the individual institution and on a multiinstitutional level. The advent of cardio-oncology as an established subspecialty and creation of networks with key stakeholders from the different disciplines will create opportunities. These networks can also facilitate collaborative funding opportunities, such as demonstrated by the recent awarding of the American Heart Association's (AHA) Strategically Focused Research Networks (SFRN). More than \$11 million was awarded during the current round of SFRN funding, with a focus of disparities in cardio-oncology, meeting an urgent and important need.

Cardiovascular Team

It has been well documented that the multidisciplinary team, including, but not limited to, nurse

practitioners, physician assistants, pharmacists, nurses, and social workers, in cardio-oncology improve patient care through optimizing outcomes, preventing complications, and reducing cost of care.²⁴ Often, the clinical challenges toward advancing patient care require various and complementary expertise of the cardiovascular team. By nature, implementation research also requires a transdisciplinary team.²⁵ Thus, it is critical to develop members of the team to be engaged in cardio-oncology implementation research and science. Given this critical point, the need to promote and advance training for the whole team is required. In addition, many funding mechanisms require a diverse team in order to successfully achieve funding. Although the full scope of each profession's education and training pathway could not be discussed due to the space limitations of the paper, there are common elements that exist for the ability to integrate both cardio-oncology and implementation research training into each profession's respective degree programs as well as in any postgraduate training opportunities, such as fellowships and/or residencies. Furthermore, the development of informal programs is needed to train team-based investigators. There are many questions germane to team science that have not been addressed in the literature including the effects of various research structures and funding mechanisms.²⁶ However, the structure, focus, opportunities, and challenges to this paradigm would not differ drastically from what has been described earlier regarding the physician pathway.¹¹

OPPORTUNITIES FOR TRAINING

Cardio-Oncology Training in General Cardiology Fellowship

As new cancer therapeutics arise and cancer survivorship is improving, there is a strong need for attentive cardiac care. Risk factors for many cancers coincide with cardiovascular disease, and cardiotoxic (ie, adverse effects of cancer therapy on the heart) cancer therapeutics further perpetuate the risk of heart disease in these patients.^{17,27–29} The ICOS and the ACC have each produced articles describing variations on a proposed conceptual framework with comprehensive training goals and standards for this subspecialty.^{11,19} In addition, a roadmap for incorporating cardio-oncology training during general cardiology fellowship was recently published by a group of worldwide experts.³⁰

Training in cardio-oncology should include a multimodality and multidisciplinary approach to address the needs of this high-risk population.

The required curriculum must include extensive educational and clinical experience with cardiovascular risk assessment before cancer therapy, management of cardiotoxicities associated with cancer treatment, ongoing cardiovascular issues in cancer patients with cancer undergoing therapy or cancer survivors, and long-term effects after immunotherapy.³¹ To screen patients with cancer for cardiotoxicity during treatment, clinicians in this field require expertise in assessing electrocardiogram (ECG) (eg, for QTc prolongation in the setting of certain cancer therapies), incorporating pertinent cardiac-specific biomarkers into practice (eg, troponin in the setting of immune checkpoint inhibitors with risk of myocarditis), and having advanced knowledge of echocardiography (including strain imaging), cardiac MRI, and coronary computed tomography (CT).^{16,19,31–35} Considering the diversity of adverse cardiac effects in response to cancer therapies, it is essential to have educational sessions with other advanced subspecialists in fields such as electrophysiology and advanced heart failure. Trainees should be exposed to cancer therapy clinical trials and be familiar with modern medical oncologic treatments.

During the clinical years, a trainee can request to work in the continuity clinic of the onsite cardio-oncologist as well as subscribe to the Journals of the American College of Cardiology (JACC): CardioOncology. To further keep up with the field and network in cardio-oncology, social media can be an engaging platform. Ultimately, the goal is to prevent, protect, and monitor patients with cancer in order to facilitate the use of life-saving cancer therapeutics. A clinician building a knowledge base in cardio-oncology will need to work with a multidisciplinary team and be involved with comprehensive care, often in structured meetings (eg, tumor board). This team typically includes hematologist-oncologists, pharmacists, and nurse navigators. Through this interdisciplinary approach, general cardiology fellows can develop a substantial cardio-oncology knowledge base. Training facilities should have at least 100 unique patients with cancer yearly.

Many general cardiology fellowships allow for up to 12 to 18 months of research during fellowship; this is sometimes strengthened by a National Institutes of Health (NIH) T32 training grant. Planning a research year dedicated to cardio-oncology research is a great opportunity to focus on cardio-oncology topics and work on individual novel research projects. For fellows without a formal research year, research can be otherwise incorporated concurrent with clinical training. On completion of research projects, trainees can

present at national cardio-oncology, cardiology, and hematology/oncology meetings. These societies and meetings include ICOS, the ACC's Advancing the Cardiovascular Care of the Oncology Patient, and the national scientific sessions of the AHA, ACC, and the American Society for Clinical Oncology (ASCO).

Cardio-Oncology Training in Hematology/Oncology Fellowship

Within a hematology/oncology fellowship training, competency is required for cancer prevention, diagnosis, care, health promotion, and the treatment of patients across genders and ages throughout the stages of a hematologic and malignant illness. Hematology and oncology fellows learn about the use of chemotherapeutic drugs and biological agents including the mechanisms of action, pharmacokinetics, and associated toxicities. These toxicities encompass both acute and chronic toxicities, such as cardiotoxicities of all types across the spectrum of heart failure, ischemic heart disease, myocarditis/pericarditis, pericardial effusions, and arrhythmias. As described by the Institute of Medicine's Crossing the Quality Chasm: A New Health System for the 21st Century, "Quality patient care is safe, effective, timely, efficient, patient-centered, equitable, and designed to improve population health, while reducing per capita costs" and remains an essential component of the hematology/oncology curriculum.^{36,37} Although Accreditation Council for Graduate Medical Education (ACGME) requirements outline specific recommendations around addressing toxicities from cancer therapies including cardiotoxicities, there remains opportunity to expand specific cardio-oncology education within the hematology/oncology training programs.^{11,19}

Embedding rotations to a cardio-oncology clinic and detailing discussions within a cardio-oncology grand rounds may be useful in addressing close collaborations between cardiology and oncology. Similarly, attending cardio oncology meetings such as the ICOS and ACC cardio-oncology meetings may be useful in expanding the oncologist's knowledge around the pathophysiology of cardiac-specific complications, the prevention of cardiac toxicities, and the long-term health of cancer survivors. In hematology/oncology fellowships as well for clinicians in practice currently, there is a growing emphasis on training in cancer survivorship.

With more than 16 million cancer survivors now in the United States,³⁸ there is increasing recognition of the need to train hematology/oncology

fellows (in both adult and pediatric programs) in the long-term manifestations of health consequences after cancer treatment, the most common of which are second malignancies and cardiovascular disease.^{39–41} In many situations, cancer survivors are more likely to die of cardiovascular disease itself as compared with recurrent cancer.⁴² Embedded within many fellowship curricula, there are opportunities to rotate within survivorship or long-term follow-up clinics for pediatric, adult, and bone marrow transplant survivors. Ensuring this curriculum in each program as opposed to select ones is essential in expanding the growth and knowledge of the cardio-oncology field. Ongoing continuing medical education (CME) events such as Cancer Center Survivorship Research Forums (ccsrf.umn.edu), the American Society of Clinical Oncology's survivorship compendium, and George Washington University's E-learning series on cancer survivorship are also valuable resources in embedding cardio-oncology curricula within hematology and oncology training.

Dedicated Cardio-Oncology Clinical Fellowship with Research

With the increasing complexity of cancer therapeutics and their potential cardiovascular side effects, there is increasing emphasis on dedicated fellowship training in cardio-oncology. Multiple cardio-oncology fellowship programs currently exist throughout the world including those affiliated with the University of Pennsylvania, Washington University in St. Louis, Vanderbilt University, and the Royal Brompton Hospital in London.⁴³ Because cardio-oncology is not yet an ACGME-accredited fellowship, various training models currently exist.^{11,19,30} Although most programs are designed to prepare board-certified/board-eligible cardiologists to manage these conditions, some programs enroll trainees who have completed internal medicine training without further subspecialization and others matriculate individuals with a medical oncology background. Most programs try to integrate both clinical and research training; however, this is not necessarily universal. The training structure needs to be tailored to the different background and skill sets of the learner. For example, a cardiology-trained cardio-oncology fellow may also want to augment their cardiovascular procedural skills, whereas a trainee without cardiology background will need to spend a significant amount of time learning the basics of cardiovascular disease management.

When working to develop a cardio-oncology fellowship, the authors suggest 3 areas of focus

over at least 1 year of training: clinical care, didactics, and research/scholarly endeavors.^{11,31} A periodic evaluation of the program's educational quality and compliance with the program's requirements will be formally implemented through the faculty and the fellow. Faculty will complete standard evaluation documents for the fellow. The ultimate success of the training will be gauged by the fellow's ability to obtain a cardio-oncology faculty position and/or develop and lead cardio-oncology programs once their training is complete.

Clinical care

A mentored experience is provided for the cardiovascular assessment of oncology patients with attention to the specific cardiotoxicities of chemotherapeutics, targeted therapies, immuno- and cell-based therapies, and radiation therapy as well as the appropriate application and interpretation of cardiac diagnostic tests (eg, ECG, imaging, and biomarkers). Specific topics that the cardio-oncology fellow will be expected to master include precancer treatment cardiovascular risk assessment, management of cancer-treatment associated cardiotoxicities, cardiac implantable device management in radiation oncology, and cardiovascular disease management in the cancer survivor.^{11,19,31,44} The fellow will be required to have no less than 100 unique patient encounters over the course of the year, as outlined in the ICOS and the CCON training document.¹⁹

The fellow will be expected to regularly participate in the established outpatient cardio-oncology clinics. In addition, he/she will be encouraged to attend outpatient oncology clinics as well as other advanced cardiology practices such as heart failure or preventative cardiology. The fellow should also participate in inpatient/acute consultative cardio-oncology services. Moreover, they are encouraged to round with different oncology inpatient services (solid tumors, liquid tumors, stem cell transplant/cellular therapies) based on individual preferences for more advanced/detailed cancer instruction. It is encouraged (but not required) that the fellow identify a particular area of focus within cardio-oncology. Over the duration of this fellowship, the trainee may tailor the experience to fit their individual needs with exposure to multimodality cardiovascular imaging (echo, nuclear cardiology, CT/MRI), advanced heart failure, preventative cardiology, or electrophysiology.

Didactic education

The cardio-oncology fellow should also receive regular didactic lectures on topics inherent to

cardio-oncology including a thorough understanding of cancer therapeutics and their potential cardiotoxicities.^{11,31,44} They will be encouraged to attend national and international cardio-oncology educational meetings including the ACC-sponsored "Advancing the Cardiovascular Care of the Cancer Patient" or the Global Cardio-Oncology Summit. Finally, the cardio-oncology fellow should also create their own didactic lectures for the general cardiovascular fellows and internal medicine residents, as this is a great method to improve knowledge and engagement. The fellow is expected to adequately complete all 7 ACGME core competencies within this fellowship. Fellows should be expected to complete the ICOS board examination at the completion of their training.

Scholarly research

Fellows will also be expected to participate in scholarly research activities that align with their clinical interests, resulting in an abstract presentation and/or article publication, as the success of the field is contingent on enhancing our knowledge of cardiotoxicities through science.^{11,31,44}

Cardio-Oncology Research Fellowship

Given the lack of formal accreditation for cardio-oncology programs, variation exists on an individual program level that may cater to the strengths of a particular program.¹¹ Research training may co-exist within the patient care framework in a clinically oriented program or be a more dedicated research-focused training in hybrid programs. One of the challenges within cardiology is the increasing duration of training across many of the subspecialties. In order to justify the incremental time spent beyond the years of training in internal medicine, general cardiology, and clinical cardio-oncology, the research aspects should serve as a foundation for next steps when transitioning into a faculty position. Ideally, it should lead to external funding opportunities from industry or from NIH/National Cancer Institute (NCI). A recent ACC training statement suggests a research project for trainees in cardio-oncology.¹¹ Level II trainees are expected to participate in a research project, whereas level III trainees are expected to complete at least 1 research project, leading to publication during their training.¹¹ In a recent survey of 16 graduated fellows from 6 institutions who completed training commensurate with level II to III cardio-oncology-specific competency between 2014 and 2020, fellows averaged 5 to 6 months of research during their 3 to 4 years of training.⁴⁵

A distinct benefit of training in cardio-oncology is the opportunity to collaborate with expansive teams with experts from both cardiology and oncology. This overlap and synergy provide access to multiple potential sources of mentors and funding. As an example, at the authors' institution the cardiology fellow working on epidemiologic breast cancer research receives guidance from a cardio-oncologist, breast oncologist, and cancer epidemiologist, ensuring a high-quality product. Although the mentor is a cardiologist/cardio-oncologist, funding for the data source is from NIH/NCI, and statistical support is provided by the oncology research team.

Training the Multidisciplinary Cardiovascular Team

The need to train the cardiovascular team in the general and specialized concepts of cardio-oncology and implementation research is critical to advancing the care of this complex population.⁴⁶ At the time of this writing there is no formalized training programs within any of the current pathways of any professions that systematically encompasses structured training and evaluation of nonphysician members of the cardiovascular team. In the present state, cardiovascular or oncology education and training is occurring in silos and either occurs through didactic means or on the job training. There exist opportunities to work collaboratively between the various cardiovascular team members professional and the cardiovascular/oncology societies to promote and develop the competencies, training programs, and certifications required to assure a competent, effective, and knowledgeable team. Ideally, the foundation education and training would encompass and mirror the same elements found for the physician teams but there will be slight modifications that would be tailored to each profession's expertise and scope.¹¹ There would need to be some urgency to the development of these programs, given the rapid expansion and ever evolving cardio-oncology field. In addition, there would need to be programs to train clinicians who are already in practice and transitioning into cardio-oncology as well as development of future cardio-oncology team members; this could be accomplished through a combination of fellowships, residencies, certification programs, and other educational programs. Finally, it is critical these programs be interdisciplinary with a research component to create a symphony within the team.

CAREER DEVELOPMENT

Journal Articles and Editorial Boards

Several journals are dedicated solely to cardio-oncology or have cardio-oncology sections, such as JACC: CardioOncology (by the ACC), CardioOncology (hosted on BMC by Springer Nature), Frontiers in Cardiovascular Medicine (Cardio-Oncology Section), Current Oncology Reports, and Current Treatment Options in Oncology. Serving as a reviewer for these journals can provide opportunities to access the most cutting-edge scientific research well before the research becomes public; this helps reviewers stay current on research and begin examining their own work through critical lens. Indeed, peer review enables improvement as a writer and, ultimately, as a published author. Peer review requires critical thinking skills that can inform subsequent academic work and assist in further developing scientific inquiry methods in one's academic career. Reviewing teaches how to be critical of one's own research. Identifying the strengths and weaknesses of others' research increases the likelihood of incorporating the strengths and avoiding the same weaknesses. As a result, serving as a cardio-oncology journal article reviewer can provide substantial benefits, expand field of vision, and generate new ideas for future research. Participating on the journals' editorial board additionally facilitates gaining an understanding of the editorial process, which will enhance one's own article submissions. Being on editorial boards also offers pathways to contribute to journal and specialty development. Serving as a reviewer then as an editorial board member can help advance lifelong learning in cardio-oncology translational and implementation science.

Didactic Meetings and Conferences

Formal and structured continuing education (CE) is also of importance for training in cardio-oncology translational and implementation science; this is relevant for all members of the multidisciplinary cardiology team, including clinicians, nurses, advanced practice providers, pharmacists, trainees, and others.¹ Among clinicians and trainees, specialties represented should include, at a minimum, cardiology (particularly cardio-oncology), medical oncology, hematology, surgical oncology, and radiation oncology. CE should be pursued by those who have completed formal training in cardio-oncology and also by those who may just be starting out in the field. CE can take many forms, especially leveraging innovative platforms and methods of learning in the Digital Era. Given the current accessibility of the global

learning community, several options for collaborative CE should be considered.

These options include attendance online or in-person at local, regional, national, and international didactic courses, meetings, and conferences, as well as participation in synchronous and asynchronous CME offerings, in addition to engaging with social media posts (eg, educational polls, quizzes, tutorials, live chats) and podcasts, along with being abreast of the latest relevant articles that are published or in press, or under consideration if encountered in the role of journal reviewer or editorial board member. The primary national meetings relevant to cardio-oncology translational and implementation science training and research are the annual scientific sessions of the AHA and ACC, the ACC Cardio-oncology course titled *Advancing the Cardiovascular Care of the Oncology Patient*, and the annual scientific sessions of the ASCO.

Also available are various summits, conferences, and symposia hosted by various academic organizations in the United States (eg, Memorial Sloan Kettering Cancer Center, Mayo Clinic, Scripps, Rush University, Duke, Washington University, Ohio State University, and the FDA). International options are also available and include the Global Cardio-Oncology Summit, Cardiology Oncology Innovation Network (COIN) Summit, Cardio Oncology Society of Southern Africa, Israel Society Cardio Oncology, Cardio-oncology International Virtual Symposium, International Colloquium on Cardio-Oncology, and National Institute on Aging/American Geriatrics Society Conference on Cancer and Cardiovascular Disease. Several institutions (eg, University of Tennessee Health Sciences Center, Moffitt Cancer Center, Duke University, and Vanderbilt University) also provide public access to their cardio-oncology grand round series. These local, regional, national, and international meetings frequently offer accredited CE and many maintain these offerings online for review long after completion of the live meetings. Innovative platforms for education are being used, with the most common being customized mobile health applications.

Role of Social Media

Social media has the potential to revolutionize CME.⁴⁷ Social media-based learning is asynchronous, allowing for access to educational content at any time or location and at one's own pace, transforming learning into something that is portable, real-time, and collaborative.⁴⁷ The microblogging site Twitter is an innovative platform for delivering continuing medical education to the health care

community, leveraging the advantages and practicalities of an untethered and collaborative learning environment.⁴⁷ Twitter enables the expansion of educational opportunities in cardio-oncology, especially during the COVID-19 pandemic.

Activities related to networking and education in the cardio-oncology social media community (commonly referred to on the microblogging platform Twitter as #CardioOnc) frequently occur around the time of major national scientific sessions for major professional societies in Cardiology and Oncology, such as the ACC, AHA, European Society of Cardiology, and ASCO.⁴⁸ Most of the participants in the social chatter surrounding these conferences are actively tweeting pearls and insights from the sessions or reactions to the scientific data. Such efforts by those in attendance and those remotely "listening" to conference chatter on social media help to increase engagement and conference-related education among cardiologists, oncologists, and hematologists worldwide, even if they are unable to attend in person; this increases access to continuing educational materials that would otherwise be restricted to in-person attendees. In particular, tweeting specifically from and about cardio-oncology sessions, posters, and gatherings at these conferences or at dedicated cardio-oncology conferences educates others currently practicing or in training to meet the growing needs of cancer survivors, which remains an important need.⁴⁹

Numerous meetings and scientific sessions have been canceled as a result of the COVID-19 pandemic. Twitter has therefore been leveraged to spread the word about educational webinars and published material in the pandemic; this will continue in the Digital Era even beyond the pandemic. #CardioTwitter is an excellent platform for reporting live from various medical conferences around the world, allowing for immediate knowledge transfer, idea exchange, and lively discussion. Perhaps this was most evident during the COVID19 pandemic, when numerous conferences went virtual.⁵⁰ Online journal clubs, chats, tutorials, and podcasts are additional emerging methods for increasing health care professionals' engagement with educational efforts on SoMe.⁵¹

Journal club

The purpose of Twitter-based journal clubs is to connect clinicians, educators, and researchers in order to discuss recent research and facilitate its dissemination.⁵² Twitter-based journal clubs that meet virtually and provide a forum for participants from a variety of disciplines and across the globe are becoming increasingly prevalent.⁵¹ Twitter

journal clubs are frequently journal-sponsored and can affect journal metrics.⁴⁷ Journal clubs may be moderated by a journal social media editor and feature at least one study investigator or special guest.⁴⁷

Twitter chat

Twitter chats are discussions that take place on Twitter at a predetermined time and date about a specific subject. Each Twitter chat is identified by a hashtag, which enables everyone on Twitter to attend or participate. To add a comment or respond to a question, Twitter users can include the chat hashtag in their tweets. Notably, a Twitter Chat campaign focused on education and advocacy in cardio-oncology accumulated ~1.2 million impressions (views by Twitter users) in 24 hours.⁵³ High engagement was noted, with tweets demonstrating (1) knowledge impartation (K), (2) advocacy awareness (A), (3) interdisciplinary collaboration (I), and (4) learning impact (L), termed "KAIL."⁵³

Tweetorials

SoMe are a brief series of multimedia tweets that contain clinical bullet point educational content on a particular subject.⁵⁴ Tweetorials are essentially condensed lectures composed entirely of linked tweets.⁵⁵ Often, tweetorials are interactive, with polls to solicit participation, step-by-step disclosure of diagnostic clues, and opportunities for questions and feedback.⁵⁴ Some educators have compiled multimedia slides into GIFs (Graphics Interchange Format) or Twitter Moments in order to deliver teaching points.⁵⁴ Many SoMe users use Threader.app to consolidate their tweetorials into a single continuous webpage posted on Twitter for easy reading.

Podcasts

Podcasts are digital audio recordings typically in the form of a series of discussions, typically with new installments delivered automatically to subscribers. Podcasts have now become frequently accessed for succinct descriptions of classic and up-to-date cardio-oncology material, and are often posted on Twitter.

SUMMARY

Heart health is becoming particularly crucial for cancer survivors, as improved survival rates have resulted in an increased frequency of survivors suffering from cardiovascular disease. As a result, the interdisciplinary field of cardio-oncology has expanded rapidly in recent years to meet the cardiovascular care needs of this distinct population through clinical care and research initiatives.

Herein, the authors have reviewed an advantageous infrastructure and system of training for career development in cardio-oncology translational and implementation science, with emphases on collaborations among scientists and the role of the multidisciplinary cardiovascular team in both research and patient care and the impact of social media in the Digital Era. Such an approach will be key to incorporate health services research training in cardio-oncology guided by appropriate implementation science frameworks. This important approach will therefore continue to be applied and assessed in the setting of established and ongoing translational and implementation science practice and training models.

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