

BMJ Open Retrospective study of medical student scholarship and career trajectory following a mentored preclinical cardiovascular summer research fellowship

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ABSTRACT

Objectives Developing a preclinical training infrastructure for cardiovascular clinician-scientists is an academic workforce priority. The Cardiovascular Research Institute of Vermont developed a cardiovascular summer research fellowship (SRF), wherein medical student awardees were selected by merit-based application and completed mentored research between the first and second years. We aimed to study the impact of the SRF on medical student scholarship and career planning.

Design Retrospective survey study.

Setting Single academic medical centre.

Participants All SRF participants from 2015 to 2020.

Interventions Not applicable.

Primary and secondary outcome measures Prior SRF participants were surveyed to ascertain current position, research engagement and perspectives regarding SRF experience. Comparisons to American Association of Medical Colleges Graduation Questionnaire data from equivalent years were made using χ^2 tests.

Results Survey response rate was 87% (20/23), 55% were women. Median time from SRF completion was 2 years (IQR 0.75–2.25), with 75% still enrolled in medical school and 25% in residency. As a result of the first-year summer programme, 45% published a peer-reviewed abstract or manuscript, which was equivalent to the national rate for graduating students (53%, $p=0.4$). Most respondents (80%) were active in additional research projects during school separate from the SRF, 90% anticipated a career involving research (vs 53% nationally, $p<0.001$) and 75% planned to pursue a career in cardiovascular medicine.

Conclusion Medical students completing a mentored cardiovascular SRF after their first year have a high rate of academic scholarship, with publication rate already equivalent to national peer graduates. Preclinical SRF students strongly anticipate cardiovascular medicine and research careers.

INTRODUCTION

Developing the academic infrastructure to train clinician-scientists remains a cardiovascular research workforce priority.¹ Engaging

STRENGTHS AND LIMITATION OF THIS STUDY

- ⇒ This study is the first description of outcomes from a mentored cardiovascular medicine research fellowship specifically designed for preclinical medical students to inspire careers in cardiovascular research.
- ⇒ Survey data from fellowship participants over the first 6 years of the programme, including a very high response rate and former students who have now entered postgraduate training.
- ⇒ This study describes a programme at a single academic institution, with comparisons made to national data to better understand the impact of the fellowship experience. The guiding principles of a preclinical cardiovascular research fellowship could be applied to other fields to establish similar programmes and inspire future clinician-scientists.

medical students in scientific inquiry early during their training may provide an opportunity to inspire careers in research.² However, despite the increasing prevalence of students performing research during medical school, only half of 2020 US graduates plan to engage in research during their careers and <3% anticipate full-time research careers.³

Early clinical exposure and mentored research experiences positively influence undergraduate students to pursue careers in research and cardiovascular medicine.⁴ Medical schools^{5, 6} and national research organisations⁷ have demonstrated associations between research during medical school and postgraduate academia. However, little is known regarding academic outcomes following a preclinical mentored cardiovascular research experience during medical school, an observation compounded by an overall under-representation of educational research in cardiovascular journals.⁸



Figure 1 SRF timeline. CVRI-VT, Cardiovascular Research Institute of Vermont; ECAC, Early Career Advisory Committee; SRF, summer research fellowship; UVM, University of Vermont.

The Cardiovascular Research Institute (CVRI) at the University of Vermont (UVM) enhances cardiovascular research by fostering interdisciplinary collaboration between the university and medical centre, encouraging critical thinking, and supporting early career development in science. In collaboration with the UVM Larner College of Medicine (LCOM), the CVRI offers an innovative preclinical medical student summer research fellowship (SRF) that provides a mentored and funded preclinical early investigator experience. We investigated the effects of the CVRI SRF on participant scholarship and career trajectory, and compared outcomes to institutional and national peers.

METHODS

We evaluated outcomes of the first 6 years of the CVRI SRF, 2015–2020. All first-year LCOM students were eligible for the SRF via merit-based application. The organised path to the SRF began during the first year with mentor identification and submission of a full proposal that included specific aims, methods, clinical significance and description of mentor support (figure 1). The CVRI Board of Directors reviewed all applications and selected final awardees. Mentors were comprised of UVM and/or LCOM faculty and staff scientists from diverse backgrounds including basic science, epidemiological and clinical research. A student stipend was provided, with additional research support supplemented by the mentor.

SRF students completed a 7-week mentored research fellowship during the summer after the first year of medical school. This structured and immersive experience was further tailored to the type of research and a student's individualised, prespecified goals. For example, some students spent the entirety of the summer in the laboratory learning new techniques and performing experiments, while others developed new skills in coding to facilitate their epidemiological research or conducted clinical research in a cardiac

rehabilitation centre. Throughout the 7-week experience, SRF participants were expected to devote full-time effort to their project and meet regularly with their mentor to monitor progress. At the SRF conclusion, all students submitted reports summarising research progress and programme experiences. There was no requirement for project completion or publication, although many students elected to continue any unfinished work throughout the remainder of medical school. The Board selected one student each year as recipient of a research merit award.

A voluntary online questionnaire was distributed in June–October, 2020 to all CVRI SRF participants since programme inception. Study data were collected and managed using REDCap electronic data capture tools hosted at The University of Vermont.^{9 10} REDCap (Research Electronic Data Capture) is a secure, web-based software platform designed to support data capture for research studies, providing (1) an intuitive interface for validated data capture; (2) audit trails for tracking data manipulation and export procedures; (3) automated export procedures for seamless data downloads to common statistical packages; and (4) procedures for data integration and interoperability with external sources. The primary aim was to describe SRF effects on participant academic scholarship (abstract or publication). Secondary aims were to describe the SRF influence on research and academic career interests in cardiovascular medicine.

Survey questions were Likert-style and multiple choice. Participants reported demographics, academic productivity, perspectives on the SRF experience, medical school activities and career interests. Burnout was self-reported and assessed as a binary variable. Several questions were structured in parallel to the Association of American Medical Colleges Graduation Questionnaire (AAMC-GQ), to allow for best-fit comparisons to institutional and national peer data.³

Standard summary statistics were used to describe survey responses. Proportions from three groups were tabulated; the CVRI SRF survey, single institution LCOM responses to the national AAMC-GQ survey and responses from the national AAMC-GQ survey from 2015 to 2020. Comparisons were made between the three groups using χ^2 goodness-of-fit test with the national AAMC-GQ survey serving as the reference group. For survey questions allowing multiple responses each category was not mutually exclusive, individual category proportions were compared using χ^2 test.

Research and ethics approval

According to UVM institutional human subjects research policy, this educational work met criteria for an operational improvement activity and was exempt from ethics review.

Patient and public involvement

Patients and public were not involved in the development of the SRF, or the design, conduct and analysis of this study.

RESULTS

The survey response rate was 87% (20/23), with respondent demographics described in [table 1](#). At the time of the survey, current training positions included medical students (75%) through postgraduate resident physicians (25%) up to the third year of training. The median time from SRF completion was 2 years (IQR 0.75–2.25). No SRF participant was in the combined MD/PhD programme. Fifty-five per cent of respondents were female. Both SRF ($p<0.001$) and LCOM ($p<0.001$) AAMC-GQ respondents were older at graduation compared with the national average. Self-reported race or ethnicity was 80% white, a greater proportion compared with the national average ($p<0.001$).

SRF participant outcomes and experiences are reported in [table 2](#). Nearly half (45%) of respondents reported authorship on a peer-reviewed abstract or publication directly related to their SRF work (7 abstracts, 3 publications). Of this scholarship, all but one publication occurred prior to medical school graduation. SRF projects encompassed all areas of cardiovascular research including basic science (35%), clinical (35%), and epidemiological research (30%). Students completing epidemiology projects reported higher rates of authorship (71%), compared with clinical (38%) and basic science (13%) projects. Thirty per cent of SRF participants received research-related awards or honours (1 national and five institutional awards) directly related to their SRF work.

Most students (80%) who participated in the SRF were also active in other research endeavours during medical school, and 30% were awarded grants later in medical school, unrelated to prior SRF work. SRF participants reported a higher rate of community-based research projects compared with national peers (75% v 32%, $p<0.001$,

[table 2](#)), but a lower rate of non-research activities such as global health experiences (0%, $p<0.001$). Among respondents now in residency training, 60% reported active research projects.

SRF participants reported more interest (90%) in a research career compared with both national (53%, $p<0.001$ SRF-GQ) and institutional (55%, $p=0.7$ LCOM-GQ) peers ([table 3](#)). Seventy-five per cent of respondents plan to work in a cardiovascular-related field. Fifty three per cent anticipated being 'significantly involved' in research and 47% 'in a limited way', with a trend towards more involvement compared with national peers (44% 'significantly involved', 53% 'in a limited way' $p=0.06$, not statistically significant). Although 95% anticipated careers including patient care, the majority were also interested in academia, including teaching (85%) and medical school faculty positions (65%).

Survey respondents were also asked to identify the most beneficial aspects of the SRF experience. Eighty per cent of participants reported receiving faculty mentorship as the most beneficial component of the SRF programme ([table 2](#)). There was an overall high satisfaction with individual mentoring during the SRF, with 100% of respondents 'very satisfied' or 'satisfied' with the experience. Furthermore, 73% felt that the individual mentoring they received from research faculty during the SRF was as helpful as or more influential than other mentoring received during medical school. When stratified by authorship, SRF participants who reported publication of peer-review manuscript or abstract were more likely to find SRF mentorship 'more influential' than other mentoring during medical school than those who had yet to publish (3.8 ± 0.8 vs 2.9 ± 0.9 , $p=0.04$; Likert scale 1=much less influential to 5=much more influential, [table 3](#)). Participants also reported other valuable elements of the SRF including the research stipend (75%), protected research time (65%), being a part of a research team (60%) and the opportunity to present at regional or national meetings (55%). Five students (25%) reported 'feelings of burnout' during medical school, with few (21%) directly attributing burnout to their research.

DISCUSSION

We describe the impact of a mentored preclinical institutional cardiovascular research experience on medical student scholarship and career planning. Our institutional data suggest that academic productivity among SRF participants while still enrolled in medical school was already equivalent to, and may exceed, the US average for students at the time of graduation. SRF participation was strongly associated with an early interest in cardiovascular medicine and high satisfaction with faculty mentorship. This pilot study suggests that if motivated students are appropriately identified and mentored, they can be academically productive and inspired to pursue academic cardiovascular medicine careers. As the academic cardiovascular science workforce is on the decline,¹¹ our

Table 1 Cardiovascular Research Institute of Vermont SRF participant characteristics with comparisons to institutional and national peers

	SRF n (%)	LCOM average (%)*	GQ average (%)†	P value SRF vs GQ	P value LCOM vs GQ
Survey responses	20 (87)	85	82		
Demographics					
Current level of training					
Medical student year	15 (75)				
2	5 (33)				
3	3 (20)				
4	7 (47)	100	100		
Residency year‡	5 (25)				
1	1 (20)				
2	1 (20)				
3	3 (60)				
Medical school graduation age (years)				<0.001	<0.001
<24	1 (5)	0	<1		
24–26	3 (15)	21	41		
27–29	10 (50)	49	42		
30–32	5 (25)	19	12		
>32	1 (5)	12	6		
Sex§				0.08	0.69
Female	11 (55)	51	49		
Male	8 (40)	49	51		
Preferred not to answer	1 (5)				
Race/ethnicity [¶]				<0.001	0.68
American Indian or Alaska Native	0	0	<1		
Asian	0	21	23		
Black or African American	0	3	6		
Hispanic, Latino or Spanish origin	1 (5)	7	9		
Native Hawaiian or Pacific Islander	0	<1	<1		
White	16 (80)	76	65		
Other	3 (15)	3	3		

*Institutional averages were derived from responses to the AAMC-GQ survey by students graduating from the University of Vermont LCOM from 2015 to 2020.

†National averages were derived from responses to the AAMC Medical School GQ from 2015 to 2020 for similar questions. SRF survey questions were structured in parallel with the AAMC-GQ to allow for better comparison.

‡Residencies included Internal Medicine (3), Paediatrics (1) and Surgery (1).

§Sex and race/ethnicity was self-reported, with categories as defined by the GQ survey.

¶Percentages may sum to greater 100% as more than one response was allowed on SRF and national surveys.

AAMC, American Association of Medical Colleges; GQ, Graduation Questionnaire; LCOM, Larner College of Medicine; PGY, postgraduate year; SRF, summer research fellowship.

study team finds these data highly relevant, timely, and important.

The SRF aims to strengthen the cardiovascular research workforce pipeline by engaging students in research earlier in their undergraduate medical training and through an individualised mentored experience. Demand for a well-prepared cardiovascular medicine workforce is expected to increase, given the heavy burden of cardiovascular morbidity and mortality in the USA, coupled with an ageing population and improved access to healthcare.¹¹ However, this unmet clinical need

must be matched with deliberate action to motivate emerging cardiovascular physicians to pursue research and academia. Barriers to successful research careers may include lack of mentorship or independent funding, availability of academic positions and the competing clinical care and teaching responsibilities of an academic career, which have altogether led some to brand cardiovascular clinician-scientists as an ‘endangered species’.¹²

One solution to workforce threats for cardiovascular clinician-scientists may be cultivating interests in cardiovascular research early in training. These initiatives should

Table 2 SRF participant outcomes, experiences and satisfaction with comparisons to institutional and national peers

	SRF n (%)	LCOM average (%)*	GQ average (%)†	P value SRF vs GQ	P value LCOM vs GQ
Outcomes					
Authorship‡	9 (45)	57	53	0.47	0.43
Peer-reviewed publication	3 (15)				
Peer-reviewed oral or poster presentation at national meeting	7 (35)				
Awards or honours related to SRF	6 (30)				
Grants awarded	6 (30)				
Experiences					
Participation in other research projects during medical school unrelated to SRF	16 (80)				
If currently in residency, participating in research	3 (60)				
Other medical school activities					
Global health	0	25	26	<0.001	0.82
Community outreach/health education	12 (60)	57	57	0.79	1
Community-based research	15 (75)	88	32	<0.001	<0.001
Most helpful aspects of the SRF					
Faculty mentoring	16 (80)				
Stipend	15 (75)				
Protected research time	13 (65)				
Being part of a research team	12 (60)				
Learning new technical or procedural skills	12 (60)				
Opportunities to present at regional/national meetings	11 (55)				
Satisfaction					
Overall level of satisfaction with SRF mentorship					
Very satisfied	15 (75)				
Satisfied	5 (25)				
Neutral	0				
Dissatisfied	0				
Very dissatisfied	0				
Suffering or suffered from burnout during medical school§					
5 (25)					
Contribution of research activities to burnout during medical school					
Contributed greatly	1 (5)				
Contributed somewhat	2 (11)				
Contributed little	1 (5)				
No effect	10 (53)				
Protected little	2 (11)				
Protected somewhat	1 (5)				
Protected greatly	2 (11)				
Did not answer	1 (5)				

*Institutional averages were derived from responses to the AAMC-GQ survey by students graduating from the University of Vermont LCOM from 2015 to 2020.

†National averages were derived from responses to the AAMC Medical School GQ from 2015 to 2020 for similar questions. SRF survey questions were structured in parallel with the AAMC-GQ to allow for better comparison.

‡Primary or coauthorship directly related to SRF work reported at the time of the survey. One respondent had one abstract and publication.

§Self-reported.

AAMC, American Association of Medical Colleges; GQ, Graduation Questionnaire; LCOM, Larner College of Medicine; SRF, summer research fellowship.

be accompanied by formal evaluation to help address the limited body cardiovascular educational research,⁸ which we hope would further and more systematically contribute

to improving clinical care outcomes. We are not aware of other studies that describe the impact of an institutional cardiovascular SRF for preclinical medical students

Table 3 SRF participants: current and future career interests with comparisons to institutional and national peers

	SRF n (%)	LCOM average (%)*	GQ average (%)†	P value SRF vs GQ	P value LCOM vs GQ
Intent to work in cardiovascular-related field	15 (75)				
Future career interests‡					
Patient Care	19 (95)	98	97	0.60	0.57
Research	18 (90)	55	53	<0.001	0.70
Teaching	17 (85)	89	83	0.81	0.12
Medical school faculty	13 (65)	56	45	0.07	0.03
Public health	6 (30)	34	29	0.92	0.28
Administration	5 (25)	28	28	0.77	1
Military service	0	4	4	0.36	1
Other	0	4	3	0.43	0.57
Degree/extent of anticipated research career				0.06	0.45
Full time	0	2	3		
Significantly involved	10 (53)	39	44		
Involved in a limited way	9 (47)	59	53		
Did not answer	1				
Influence of SRF on career planning					
Very useful	5 (25)				
Moderately useful	6 (30)				
Somewhat useful	8 (40)				
Not useful	1 (5)				
Influence of SRF mentoring as compared with other mentoring during medical school					
Much more influential	3 (15)				
More influential	4 (20)				
Neutral	9 (45)				
Less influential	4 (20)				
Much less influential	0				

*Institutional averages were derived from responses to the AAMC-GQ survey by students graduating from the University of Vermont LCOM from 2015 to 2020.

†National averages were derived from responses to the AAMC Medical School GQ from 2015 to 2020 for similar questions. SRF survey questions were structured in parallel with the AAMC GQ to allow for better comparison.

‡Percentages may sum to greater 100% as more than one response was allowed on SRF and national surveys.

§Primary or coauthorship directly related to SRF work reported at the time of the survey. Some respondents had more than one abstract or publication.

AAMC, American Association of Medical Colleges; GQ, Graduation Questionnaire; LCOM, Larner College of Medicine; SRF, summer research fellowship

wherein participation was associated with increased interest in pursuing careers in cardiovascular research. National data indicate research interest declines during the later clinical years of medical school, as in 2019 a higher percentage of matriculating students (62%)¹³ anticipated a career in research than graduating students (51%).³ Single institutions have reported that research activity in medical school is associated with pursuing a residency at an academic medical centre,⁵ and institutional mentored research programmes for preclinical students in non-cardiovascular specialties have shown that early experiences foster specialty-specific interest, lead to scholarship, and stimulate interest in academic careers.^{14–18} However, while some longitudinal institutional research fellowships¹⁹ have described associations between fellowship

participation with academic productivity and matching in competitive residency programmes, many institutional programmes of similar scope to the SRF lack the long-term follow-up^{14–18} that has been reported by large national research organisations that have described the association of medical student research fellowship participation with successful academic medical careers.⁷

Individualised mentorship appears critical to create a positive research experience and foster further academic interests. This study observed that faculty mentorship was the most beneficial aspect of the SRF, valued by 100% of respondents. Furthermore, SRF participants who published were more likely to find SRF mentorship more valuable than other mentorship received during medical school. The presence of a role model or research mentor

may be one of the most important factors that influences a medical student's decision to pursue a research career.⁶ While 83% of graduating medical students in the 2020 AAMC-GQ performed research with a faculty member, only 3% planned to pursue full-time research, suggesting that the presence of a mentor alone may not be enough to inspire the next generation of clinician-scientists.³ Supported by our findings, we postulate it may be more important that mentorship is tailored to a student's specific needs and interests. Further follow-up of our programme will provide more insight on this hypothesis, including study of faculty mentors.

While the publication rate at the time of the survey was similar to the national average for graduating medical students, a crucial acknowledgement is that 75% of the SRF cohort has yet to graduate, and of this subgroup, 47% report ongoing active work on cardiovascular manuscripts. Our SRF data also suggest that a positive experience in research early in medical school may beget further research interests: 87% of respondents were active in additional research (non-SRF related), which is greater than the national average (79%) for research activity of any kind. Despite SRF projects that were distributed almost equally across fields (basic science, clinical and epidemiology), participants completing epidemiology projects reported a higher rate of peer-reviewed abstract or publication, followed by clinical and basic science research. These institutional data are limited by small sample size in each research domain; however, the observed frequency of scholarship to date may be influenced by inherent differences in project scope or duration, methodology, availability of resources and mentorship. The SRF programme may benefit from further internal review and discussion among faculty mentors to identify successes and barriers to student scholarship, in order to improve the SRF student experience.

Although extracurricular research in medical school likely increases the cognitive load for students,²⁰ the relationship between medical student research and trainee burnout has not been well described. Burnout was self-reported as a binary variable and was not assessed with a formal burnout inventory questionnaire. In our SRF cohort 25% of respondents reported suffering from burnout in medical school, which is well below the national average (45%–71%).²¹ This may reflect that those who chose the SRF were more resilient; 79% of respondents reported that the SRF had either no effect on or served to protect against burnout. This finding may underscore the importance of individualised mentorship and personalised experiences that may serve to reframe the perceived stress from extracurricular research activities in medical school.

Limitations of this study should be considered, including that the SRF survey results may be prone to selection bias influenced by baseline demographics, interests and LCOM curricular structure. To address these factors and provide institutional context, we performed comparisons between LCOM-GQ data and national AAMC-GQ data.

For example, most preclinical students at LCOM participate in a structured public health projects course, which may explain the significant differences in self-reported 'community-based research project' activity in both the SRF and LCOM GQ surveys compared with national data. Additionally, 90% of SRF awardees anticipate a career involving research, compared with 53% nationally and 55% of institutional peers. The SRF application acceptance rate during the 6-year study period was 85%; the majority of rejected applications were based on subject (ie, 'unrelated to cardiovascular research') rather than scientific merit. Altogether, this suggests that bias from SRF awardee selection may be limited (most applicants were accepted), but that in general applicants more likely self-select for the SRF with higher baseline interest in research and/or cardiovascular-related medicine than their peers, and this may confound the observed success of SRF students. Direct comparison between SRF, LCOM and AAMC-GQ groups was not possible due to lack of complete independence among the survey populations. Most respondents to the LCOM survey also completed the AAMC-GQ survey and thus these groups are not independent, but the small number of students overlapping would not substantially impact comparisons (ie, average 15 882 respondents to AAMC-GQ from 2015 to 2020 and 99 for LCOM).

Recruitment and inclusion of diverse student participants remain an area of importance for the SRF and the cardiovascular field. While the proportion of female respondents to the SRF survey was similar to LCOM and AAMC-GQ gender reporting, women remain overall under-represented in cardiology and cardiovascular medicine²² and thus we are proud that over half of SRF awardees have been women. While the overall SRF acceptance rate was high and the prevalence of female respondents in this study more likely reflective of those who applied for the SRF, we cannot exclude influence from institutional prioritisation of diversity, equity and inclusion at UVM, which we consider to be positive for the SRF and the cardiovascular workforce. In contrast, SRF participants were more often white compared with national data and there were no black or Asian SRF participants. The low representation of non-white race/ethnic participants generally reflects the student profile of LCOM, and requires concerted effort to enhance appeal of LCOM to students of colour, and the appeal of cardiovascular science across race/ethnic groups.

While publications and funding are two objective measures, the data describing career trajectory in our study were self-reported and anticipatory. To better understand the impact of the SRF, future studies should include a pre-SRF survey, LCOM student control group and a survey of SRF mentors to ascertain their perspectives. Longer and more structured follow-up of SRF participants, including publications, future funding, and academic appointments in cardiovascular-related fields will allow us to further understand how preclinical research experiences ultimately

translate into the development of career cardiovascular clinician-scientists.

CONCLUSION

An institutional cardiovascular science SRF provides an important opportunity to mentor preclinical medical students and inspire clinician-scientists. This study of SRF participants demonstrated that medical students who completed a mentored summer research experience after their first year already published at the national average for graduating students, even though the majority had yet to graduate and reported ongoing work, suggesting they may outperform their national peers by the time of graduation. While preclinical SRF students strongly anticipate careers in research and cardiovascular medicine, further educational studies are warranted to evaluate the longer-term impact of the SRF impact on clinician-scientist scholarship and career trajectory.

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Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval According to University of Vermont institutional human subjects research policy, this educational work met criteria for an operational improvement activity and was exempt from ethics review. Participants gave informed consent to participate in the study before taking part.

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Data availability statement Data are available upon reasonable request. All data relevant to the study are included in the article or uploaded as supplementary information. Individual survey data available upon a reasonable request.

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REFERENCES

- Ley TJ, Rosenberg LE. The physician-scientist career pipeline in 2005: build it, and they will come. *JAMA* 2005;294:1343–51.
- Dickler HB, Korn D, Gabbe SG. Promoting translational and clinical science: the critical role of medical schools and teaching hospitals. *PLoS Med* 2006;3:e378.
- Association of American Medical Colleges. Medical school graduation questionnaire: 2020 all schools summary report; 2020 [Accessed 13 Mar 2021].
- North M, Harris K, Garberich R, Traverse J, et al. Cardiology research internship for undergraduate students provides unique opportunity for next generation of health care professionals. *J Am Coll Cardiol* 2020;75:3655.
- Conroy MB, Shaffiey S, Jones S, et al. Scholarly research projects benefit medical students' research productivity and residency choice: outcomes from the University of Pittsburgh school of medicine. *Acad Med* 2018;93:1727–31.
- Ha TC, Ng S, Chen C, et al. Inclination towards research and the pursuit of a research career among medical students: an international cohort study. *BMC Med Educ* 2018;18:86.
- Lowenstein CJ, Weisfeldt ML, Mitchell JH. Sarnoff cardiovascular research Foundation: Inspiring the physician-scientists of tomorrow. *Circulation* 2018;138:554–6.
- Allred C, Berlacher K, Aggarwal S, et al. Mind the gap: representation of medical education in Cardiology-Related articles and journals. *J Grad Med Educ* 2016;8:341–5.
- Harris PA, Taylor R, Thielke R, et al. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform* 2009;42:377–81.
- Harris PA, Taylor R, Minor BL, et al. The REDCap Consortium: building an international community of software platform partners. *J Biomed Inform* 2019;95:103208.
- Narang A, Sinha SS, Rajagopalan B, et al. The supply and demand of the cardiovascular workforce: striking the right balance. *J Am Coll Cardiol* 2016;68:1680–9.
- Fuster V, van der Zee S, Elmariah S, et al. Academic careers in cardiovascular medicine. *Circulation* 2009;119:754–60.
- Association of American Medical Colleges. Medical Matriculating student questionnaire: 2019 all schools summary report; 2019 [Accessed 13 Mar 2021].
- Brueckner-Collins JK, Stratton TD, Conigliaro RL. Inspiring the next generation of academic physicians: the academic health careers program. *Med Educ Online* 2018;23:1530559.
- Shah P, Sheng M, Mankoff DA, et al. Impact of early radiology research experiences on medical student perceptions of radiology and research. *Curr Probl Diagn Radiol* 2019;48:423–6.
- Fricke TA, Lee MGY, Brink J, et al. Early mentoring of medical students and junior doctors on a path to academic cardiothoracic surgery. *Ann Thorac Surg* 2018;105:317–20.
- Corcoran K, Weintraub MR, Silvestre I, et al. An evaluation of the score program: a novel research and mentoring program for medical students in Obstetrics/Gynecology and otolaryngology. *Perm J* 2020;24. doi:10.7812/TPP/19.153. [Epub ahead of print: 16 04 2020].
- Schwartz L, Luban N, Hall A, et al. The mentored experience to enhance opportunities in research (METEOR) program. *Med Educ Online* 2022;27:2014290.
- Areephanthu CJ, Bole R, Stratton T, et al. Impact of professional student Mentored research fellowship on medical education and academic medicine career path. *Clin Transl Sci* 2015;8:479–83.
- Hill MR, Goicochea S, Merlo LJ. In their own words: stressors facing medical students in the millennial generation. *Med Educ Online* 2018;23:1530558.
- Ishak W, Nikravesh R, Lederer S, et al. Burnout in medical students: a systematic review. *Clin Teach* 2013;10:242–5.
- Curtis AB, Rodriguez F. Choosing a career in cardiology: where are the women? *JAMA Cardiol* 2018;3:691–2.