

Impact of a Respiratory Disease Young Investigators' Forum on the Career Development of Physician-Scientists

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ABSTRACT

Background: To reverse the dramatic decline in the U.S. physician-scientist workforce, interventions are necessary to retain physicians in research careers.

Objective: To evaluate the impact of an annual 3-day symposium, the Respiratory Disease Young Investigators' Forum (RDYIF), designed to guide fellows and junior faculty into successful physician-scientist careers.

Methods: In this retrospective, observational study, a questionnaire was e-mailed to 308 physicians who participated in the RDYIF between 2005 and 2018. The questionnaire was administered by National Jewish Health study personnel in the spring of 2019. Responses were primarily analyzed using descriptive and qualitative approaches.

Results: The response rate was 39.3% ($n = 121$), with 107 of responders (88.4%) completing the full survey. The majority of survey completers currently worked as physician-scientists (76.6%; $n = 82$), held faculty positions (88.8%; $n = 95$) in an academic center (90.6%; $n = 97$), and were currently involved in research (93.4%; $n = 100$). The majority had been an author on ≥ 10 peer-reviewed publications (61.3%, $n = 65$) and had been awarded research grants (71.7%; $n = 76$). Thirty completers (28.3%) had served as a principal investigator on one or more clinical trials. Completers indicated that participation in the RDYIF had a "strong impact" or "very strong impact" on their career development as physician-scientists.

Conclusion: Participation in the RDYIF strengthened participants' interest in physician-scientist careers and appeared to track with successful career development. Young Investigator Forums such as the RDYIF may be an effective intervention to support the declining supply of physician-scientists in North America.

Keywords:

physician-scientists; career development; mentoring; basic science research; clinical research

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Physician-scientists have been defined as “those with an MD/DO degree (alone or combined with other advanced degrees) who devote a substantial percentage of their professional efforts to research anywhere along the entire spectrum of biomedical inquiry, ranging from basic science, through translational and patient-oriented research, to the evaluative sciences” (1). Uniquely positioned to make clinically relevant discoveries as a result of their interdisciplinary and rigorous training in clinical medicine and research methodology, physician-scientists develop and implement new diagnostic modalities to advance preventive and therapeutic interventions.

The number (and percentage) of U.S. physicians who report research as their major professional activity has fallen steadily from its peak of 23,268 (4.7%) in 1984 to 13,447 (1.6%) in 2011 (2). In 2014, the National Institutes of Health (NIH) Physician-Scientist Workforce Working Group predicted that the physician-scientist workforce will continue to decline because there are too few younger physician-scientists to replace those over the age of 61 who will retire (3). The task force called for effective measures to encourage more trainees to enter the physician-scientist “pipeline” and to prevent loss of candidates to alternate careers (3, 4). If not remedied, shortages in the physician-scientist workforce will negatively impact biomedical research productivity in the United States for many years (5, 6).

The decline in the number of medical students and physicians pursuing physician-scientist careers can be attributed to a number of challenges, including a high educational debt burden, a lengthy training period, stiff competition for research funding, a lack of institutional support for research, the challenges of maintaining work/life balance, requirements for maintaining board certification, and difficulties in finding adequate mentors and role models (2–8).

To date, most publications on approaches to increase the number of trainees in the physician-scientist pipeline have focused on programmatic, policy, or funding strategies at the institutional or national level (4–6, 9–12). Comparatively little attention has been paid to the importance of acquiring effective scientific communication (13), networking, and collaboration (9, 14, 15) skills, even though these competencies are essential for a successful research career.

PROGRAM OVERVIEW

The Respiratory Disease Young Investigators’ Forum (RDYIF) is an annual 3-day symposium that was created to identify and prepare outstanding candidates for successful careers as physician-scientists. The first forum began in 2004 through a collaboration between Scientific Therapeutics Information, Inc. (a medical communications company), AstraZeneca Pharmaceuticals LP, and the Division of Pulmonary Disease and Critical Care Medicine at the University of North

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This article has a related editorial.

Carolina at Chapel Hill. In 2014, National Jewish Health (NJH), an academic medical center in Denver, Colorado, and an Accreditation Council for Continuing Medical Education–accredited provider, began certifying the RDYIF for continuing medical education credit. In 2017, NJH became the sponsor overseeing all aspects of program development and execution. Funding for the forum is provided through an independent educational grant from AstraZeneca Pharmaceuticals LP.

The overall objective of the RDYIF is to help enable young physicians involved in basic or clinical research to engage in best practices for research study design, refine research presentation and scientific communication skills, and develop networking and grant-writing capabilities. Physicians (M.D.s and D.O.s) who were enrolled in U.S. fellowship programs in pediatric or adult pulmonary/critical care medicine, allergy, or immunology programs, and physicians who had recently (within 2–5 yr) transitioned from a fellowship to an academic faculty position in these disciplines were eligible to apply to participate in the RDYIF. Invitations were distributed annually, from 2004 to 2009 and from 2011 to 2018, via direct mailings to U.S. academic fellowship program directors and past RDYIF participants and faculty, and through press releases and announcements in subspecialty journals and digital media.

Applicants submitted abstracts in either of two research categories (basic or clinical science) on the topics of asthma, chronic obstructive pulmonary disease, cystic fibrosis, interstitial lung disease, pulmonary vascular disease, lung transplantation, allergic rhinitis, the genetics of airway diseases, sleep, and bronchiectasis. Abstract submissions in each of the two research categories were scored and ranked on scientific importance, quality of research,

potential to enhance knowledge, relevance of the research question, and overall presentation by the RDYIF faculty, who were blinded to the identities of the applicants. Approximately 30–40 young investigators were invited annually to participate in the RDYIF from an applicant pool of 30–60 individuals, based on abstract rankings. Throughout the 3-day forum, young investigators had the opportunity to rehearse, refine, and subsequently present their research to a panel of expert faculty and peer investigators. Mentoring and networking opportunities were cultivated through the intimate nature of the forum, with meals and lodging arranged to facilitate relationship-building among expert faculty, research advisors, and young investigators. Over the years, the RDYIF faculty has varied in composition, but has consisted of a program chair, a cochair, and a panel of 6–12 prominent physician-scientists selected by the program chairs based on the relevance of their research experience in respiratory medicine. Three research advisors who were similarly selected attended the forum on the first afternoon to provide one-on-one mentoring and recommendations for improvement during rehearsal sessions before the official start of the forum. Authorship of this paper was led by four physician faculty who have served as both program chairs and expert faculty members for the forum at various points over the past 15 years.

The purpose of this study was to evaluate the impact of the RDYIF on the career development and productivity of fellows and early-career physician faculty who participated in the RDYIF between 2005 and 2018. Information obtained from this study will be used to inform future forums and to make data-driven improvements

aimed at attracting the best and brightest young investigators in respiratory medicine.

METHODS

A total of 379 past participants were identified using attendance records from RDYIFs held annually from 2005 to 2009 and from 2011 to 2018 (no forum was held in 2010 owing to a lack of funding). Approximately 40 participants from the 2004 RDYIF were excluded because attendance records for that event could not be found. Of the 379 participants, 308 had an e-mail address that did not return an automated “no reply” response and could be verified using RDYIF attendance records, social media platforms, or a place of employment website. A brief description of the study and an electronic link to an anonymous, voluntary, self-administered online questionnaire were e-mailed to these 308 participants by the NJH Office of Professional Education in April 2019, followed by weekly e-mail participation reminders for a period of 5 weeks. Study data were collected and managed using REDCap (projectredcap.org) electronic data capture tools hosted at NJH (16, 17). REDCap is a secure, web-based software platform designed to support data capture for research studies.

The questionnaire consisted of a total of 66 items, used embedded logic to determine the next question according to previous responses, and was developed by the Office of Professional Education at NJH in collaboration with the study authors. The content validity of the questionnaire was established by individuals with expertise as physician-scientists, prior participants in the RDYIF, and individuals involved in planning the RDYIF. In addition, a pilot test of the survey was completed with a small local sample ($N=4$) of past participants employed at NJH before the survey was

distributed to the larger group. The questionnaire sought to collect basic demographic details (sex, race, degree[s], medical specialty, and current employment), in addition to information about faculty rank, publications, grants, leadership roles in clinical trials, research participation, work as a physician-scientist (defined in the questionnaire as “those with an MD degree [alone or combined with other advanced degrees] who devote a substantial percent of their professional efforts to research anywhere along the entire spectrum of biomedical inquiry, ranging from basic science, through translational and patient-oriented research, to the evaluative sciences” [1]) and perceived barriers to continuing work as a physician-scientist. Likert-type and open-ended response items sought participants’ retrospective assessments of the impact of the RDYIF on their careers, in addition to suggestions for improving the RDYIF. The NJH Institutional Review Board deemed the study to be exempt from review.

Survey data were analyzed using SAS version 9.4 (SAS Institute). Questions were separated into three types: specific answer, short open-ended, and long open-ended. Responses to specific-answer questions and short open-ended questions were analyzed using basic descriptive approaches (e.g., frequency tables and bar charts). Responses to long open-ended questions were analyzed using specific keyword searches and then tabulated into frequency tables; these responses were also reviewed and described in a more qualitative manner.

Fisher’s exact test was used to compare completers with noncompleters, completers who had dual degrees with those who had only one degree, and research type by faculty position. Levels of productivity (authorship, grants, and role as a principal

investigator [PI]) were compared between dual and non-dual degree holders using Wilcoxon rank sum (WRS) tests. All tests were two-sided, and no specific α level was set for significance. Rather, specific *P* values were reported and used to assess the level of dissimilarity between groups.

RESULTS

Out of a total of 308 survey recipients, 121 (39.3%) responded. Of the 121 who started the survey, 107 (88.4%) completed it (“completers”); 14 “noncompleters” started the survey but did not finish it. Of the survey completers, 45.8% were female and 54.2% were male (Table 1). The majority of completers (66.4%) described their race as white and the majority (78.5%) had attended medical school in the United States. Of 106 completers, 35 (33.0%) first participated in the RDYIF in 2009 or before 2009, 38 (35.8%) participated between 2011 and 2015, and 33 (31.1%) participated between 2016 and 2018. Ninety-one completers (85.0%) were fellows and 16 (15.0%) were junior faculty when they participated in the RDYIF. The majority of completers had earned either an M.D. degree (83.2%) or both an M.D. and a Ph.D. degree (13.1%). The current subspecialty for most of the completers was either pulmonary and critical care (68.2%) or pulmonary medicine (16.8%). Basic demographics (sex, race, first year of RDYIF participation, role, degree type, and current faculty rank) did not differ significantly between completers and noncompleters ($P > 0.1$).

Career Development

The majority of completers (76.6%) were currently working as physician-scientists (Table 2). Among individuals who were not working as physician-scientists ($n = 25$), most ($n = 21$; 84.0%) had never worked in

that capacity and only four (16.0%) reported that they had previously worked as a physician-scientist. Raw data counts are presented in Table 2 rather than percentages because some individuals who responded to “other” may have selected more than one answer option.

The 25 individuals who did not describe themselves as physician-scientists were asked the open-ended question, “Why did your career take you in another direction?” A qualitative analysis of free-text responses to this question revealed four main themes: a preference for or transition to clinical work ($n = 10$; 41.7%); lack of research funding, mentoring, or institutional support ($n = 10$; 41.7%); perceived negative impact of a physician-scientist career on quality of life ($n = 2$; 8.3%); and other (e.g., “personal choice”) ($n = 2$; 8.3%). Of note, of the 24 respondents to this question, 6 described themselves as currently involved in research in a limited capacity.

Productivity

Most individuals (61.3%) had been an author on 10 or more peer-reviewed publications, and most had served as first or senior/corresponding author on 4 or more peer-reviewed publications (60.8%) and as second author on 1 or more peer-reviewed publications (75.2%). The median number of peer-reviewed publications authored by the group ($n = 106$) was 13. The median number of first or senior/corresponding authorships and second authorships was 5 ($n = 102$) and 2 ($n = 97$), respectively. Among non-peer-reviewed works, the most frequently authored or coauthored type was a review article (66.4%), followed by a book or book chapter (62.6%), a case report or case series (44.9%), an editorial (34.6%), an observational study (21.5%), a guideline (9.4%), a consensus statement (8.4%), a

Table 1. Characteristics of the survey completers

	<i>n</i>	%
Sex		
Female	49	45.8
Male	58	54.2
Race		
American Indian or Alaskan native	0	0
Asian	29	27.1
Black	2	1.9
Native Hawaiian or other Pacific Islander	0	0
White	71	66.4
More than one race	3	2.8
Unknown or unreported	2	1.9
Year participated in RDYIF*		
2009 or prior	35	33.0
2011–2015	38	35.8
2016–2018	33	31.1
Role when participated in RDYIF		
Fellow	91	85.0
Junior faculty	16	15.0
Degree(s)		
D.O.	1	0.9
M.D.	89	83.2
M.D. and M.P.H.	2	1.9
M.D. and M.S.	1	0.9
M.D. and Ph.D.	14	13.1
Medical school location		
United States	84	78.5
Outside of United States	23	21.5
Current medical subspecialty		
Allergy	4	3.7
Allergy and immunology	4	3.7

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Table 1. Characteristics of the survey completers (continued)

	<i>n</i>	%
Critical care	1	0.9
Ear, nose, and throat	1	0.9
Pediatric pulmonary	1	0.9
Pulmonary medicine	18	16.8
Pulmonary and critical care	73	68.2
Pulmonary and pediatric pulmonary	1	0.9
Pulmonary, critical care, and interventional pulmonology	1	0.9
Pulmonary, critical care, and sleep	2	1.9
Pulmonary, critical care, and other	1	0.9

Definition of abbreviation: RDYIF = Respiratory Disease Young Investigators' Forum.

*The RDYIF was not held in 2010 owing to a lack of funding.

meta-analysis (7.5%), or other work type (7.5%).

The majority of the 106 individuals (71.7%) who responded to a question about grant funding had received grants to support their research. Forty-five individuals (65.2%) had received one or more K series awards, 2 (3.3%) had received one or more P series awards, 5 (8.3%) had received one or more U series awards, 15 (24.6%) had received one or more industry grants, and 59 (80.8%) had received one or more foundation grants. Based on free-text responses to an open-ended question about "other" grants, 15 individuals had received one or more R series awards, and 28 had received other types of grants. Among those who completed the forum before 2013, 89% ($n = 17/19$) had received one or more NIH grants, and among those who completed the forum after 2013, 50% ($n = 15/30$) had obtained one or more NIH grants ($P = 0.006$ for Fisher's test).

Nine (8.9%) of the respondents who were fellows at the time of their participation in

the RDYIF had later been invited to participate in an RDYIF as faculty.

Table 3 highlights participants' responses related to authorship, research endeavors, and funding.

Comparison of Dual and Non-Dual Degree Holders

Dual degree holders were defined as individuals who had an M.D. and a Master of Public Health degree (M.P.H.), an M.D. and a Master of Science degree (M.S.), or an M.D. and a Ph.D. (M.D.-Ph.D.). Among completers, faculty ranks were very similar between dual and non-dual degree holders ($P = 0.82$). Dual degree holders had a higher median number of authored papers (dual ≥ 20.5 ; non-dual ≥ 11.5 ; $P = 0.07$). Completers with dual degrees tended to have a higher median number of first-authored papers (dual ≥ 10 ; non-dual ≥ 5 ; $P = 0.07$ [WRS test]) and had served as a PI on more clinical trials (dual ≥ 3 , non-dual ≥ 2 ; $P = 0.75$ [WRS test]), although this did not reach statistical significance. Eighty-eight percent of dual

Table 2. Career development

	<i>n</i>	%
Are you currently working in a physician-scientist capacity?*		
Yes	82	76.6
No	25	23.4
Previously worked as physician-scientist	4	16.0
Never worked as physician-scientist	21	84.0
If you are a faculty member, what is your current rank?		
Instructor	19	20.0
Assistant professor	47	49.5
Associate professor	27	28.4
Professor	1	1.0
Other [†]	1	1.0
In what setting do you primarily work?		
University or academic medical center	97	90.6
Hospital	5	4.7
Private practice	3	2.8
Industry	1	0.9
Government	1	0.9
How many years have you worked at your current place of employment?		
0 yr	2	1.9
More than 0 and less than 5 yr	42	39.3
At least 5 and less than 10 yr	42	39.3
At least 10 yr	21	19.6
How many institutions have you worked for since graduating from your fellowship program?		
0	4	3.8
1	82	77.4
2	15	14.2
3	5	4.7
Does your current role involve research?		
Yes	100	93.4
No	7	6.5

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Table 2. Career development (continued)

	<i>n</i>	%
What percentage of effort does research comprise in your current role?		
0%	3	3.1
1–29%	18	18.6
30–74%	20	20.6
75%	29	29.9
>75%	27	27.8
What type of research do you do?		
Basic science	11	11.1
Clinical	33	33.3
Translational	23	23.2
Other	4	4.0
Combination of two or more of the above	28	28.3
What is your primary area of research?		
Asthma	19	19.2
Allergy	4	4.0
Chronic obstructive pulmonary disease	14	14.1
Cystic fibrosis	8	8.1
Interstitial lung disease	11	11.1
Public health	1	1.0
Sleep medicine	3	3.0
Other	39	39.4

*Definition of physician-scientist presented in questionnaire: "Physician-scientists are those with an MD/DO degree (alone or combined with other advanced degrees) who devote a substantial percent of their professional efforts to research anywhere along the entire spectrum of biomedical inquiry, ranging from basic science, through translational and patient-oriented research, to the evaluative sciences" (1).

[†]This individual described his/her status as "adjunct."

degree holders had received a research grant, compared with 69% of non-dual degree holders ($P=0.14$); however, a greater proportion of non-dual degree holders had served as a PI on a clinical trial compared with dual degree holders (31% vs. 18%; $P=0.38$). A higher percentage of dual degree holders had been awarded at least one NIH K series award (dual $\geq 77\%$; non-dual $\geq 62.5\%$; $P=0.08$).

Comparison of Research Type by Faculty Rank

The types of research conducted by faculty of different ranks were compared (Table 4). Similar percentages of junior faculty (instructors and assistant professors) and associate professors were involved in basic science research (30.2% vs. 28.0%, respectively). It should be noted that these two groups are statistically

Table 3. Career productivity

	<i>n</i>	%
On how many peer-reviewed publications have you been an author?		
0	1	0.9
1–4	20	18.9
5–9	20	18.9
10 or more	65	61.3
Median number (<i>n</i> = 106): 13		
On how many peer-reviewed publications did you serve as first or senior/corresponding author?		
0	6	5.9
1	14	13.7
2	10	9.8
3	10	9.8
4 or more	62	60.8
Median number (<i>n</i> = 102): 5		
On how many peer-reviewed publications did you serve as second author?		
0	24	24.7
1	14	14.4
2	23	23.7
3	12	12.4
4 or more	24	24.7
Median number (<i>n</i> = 97): 2		
Please identify other works you have authored or coauthored. (Respondents could choose more than one type.)		
Review	71	66.4
Book or book chapter	67	62.6
Case report or case series	48	44.9
Editorial	37	34.6
Observational study	23	21.5
Guideline	10	9.4
Consensus statement	9	8.4
Meta-analysis	8	7.5
Other	8	7.5

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Table 3. Career productivity (continued)

	<i>n</i>	%
How many times have you served as a PI on a clinical trial?		
0	76	71.7
1	11	10.4
2	4	3.8
3	6	5.7
4 or more	9	8.5
How many times have you served as a co-PI on a clinical trial?		
0	72	67.9
1	11	10.4
2	9	8.5
3	3	2.8
4	2	1.9
5 or more	9	8.5
Have you received grants to support your research?		
Yes	76	71.7
No	30	28.3
Number of individuals who had received one or more grants of the following types*:		
NIH K series	45	65.2
NIH R series [†]	15	—
NIH P series	2	3.3
NIH U series	5	8.3
Industry	15	24.6
Foundation	59	80.8
Other [‡]	28	—
If you were a fellow when you attended the RDYIF, were you invited later to participate as faculty?		
Yes	9	(8.9)
No	92	(91.1)

Definition of abbreviations: NIH = National Institutes of Health; PI = principal investigator; RDYIF = Respiratory Disease Young Investigators' Forum.

*For each grant type, percentages were calculated using the total number of individuals who indicated the number of grants received, including those who responded with "0."

[†]The total number who had received an R award was calculated by counting how many individuals mentioned R awards in a free-text response to an open-ended question about "other" grants received. Therefore, the percentage of R awards could not be calculated.

[‡]Twenty-eight individuals indicated that they had received "other" types of grants. This category excludes those who reported they had received an R award.

Table 4. Relationship of research type to faculty rank*

	Instructor	Assistant Professor	Associate Professor
Basic science	3	5	2
Clinical	3	16	11
Translational	7	11	5
B+C	1	0	1
B+T	2	7	1
B+C+T	0	1	3
C+T	2	5	1
C+T+other	0	0	1
Total	18	45	25
Any basic science [†]	6 (21%)	13 (46%)	7 (25%)
No basic science [†]	12 (19%)	32 (52%)	18 (29%)

Definition of abbreviations: B = basic science; C = clinical; T = translational.

*In the group of survey completers, there was only one professor and one adjunct. Neither individual responded to the question about research type and neither was included in this table.

[†]Row percentages are given in parentheses.

equivalent. Using research categories of clinical only, combination, and translational and basic science only, and faculty rank categories of instructor, assistant professor, and associate professor, Fisher's exact test yielded $P = 0.59$ ($n = 88$), indicating no strong relationship between research type and rank.

Comparison of Research by Sex

There is some indication that men have greater numbers of authored (or coauthored) papers than women ($P = 0.0005$) and first-authored papers ($P = 0.04$): 74% of men had at least 10 coauthored or authored papers, and 40% of women had at least 10 publications; 47% of men, but only 22% of women, had at least 10 first- or senior-authored papers. Thirty-six percent of men had served as a PI, versus 20% for women ($P = 0.09$). Men had more industry grants (38% vs. 7% for women, $P = 0.007$). For other grants, men

tended to have more than women, but not significantly. These results were obtained using Fisher's exact test, based on the 107 completers.

Impact of the RDYIF on Career Development

A Likert-type scale (negative impact, no impact, neutral, strong impact, or very strong impact) was used to assess the impact of RDYIF participation on eight factors associated with career development. Figure 1 highlights the impact of the RDYIF on these eight factors.

When asked if they thought the RDYIF offers value and should be continued, 100% of completers ($n = 106$) answered "yes." When asked if they would recommend the RDYIF to current fellows as a good professional development opportunity and resource, 100% ($n = 105$) answered "yes." In addition, 50% ($n = 53$) of completers indicated they had stayed connected with

Impact of RDYIF on Career Development

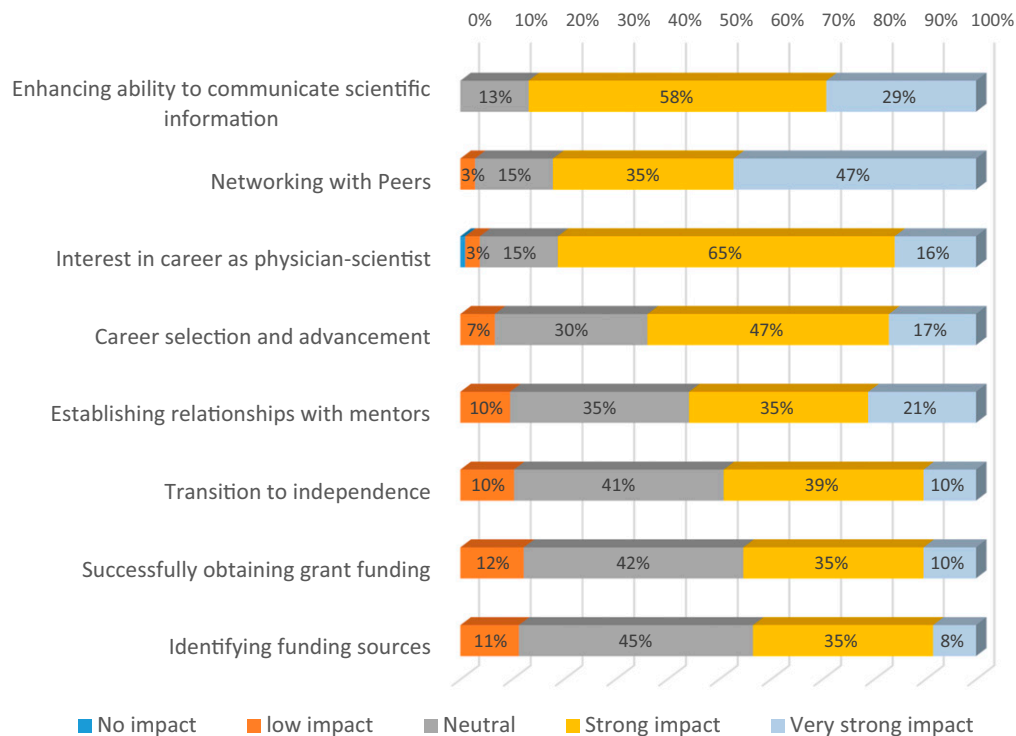


Figure 1. Assessment of the impact of Respiratory Disease Young Investigators' Forum (RDYIF) participation on career development. In response to the request "As it relates to your career, please rate the degree to which you feel the RDYIF had an impact on the following factors," selections included "no impact," "low impact," "neutral," "strong impact," and "very strong impact."

other young investigators from the event they attended.

Four open-ended questions aimed to elicit participants' feedback on the overall impact of the RDYIF on their careers. Representative free-text responses are presented in the data supplement. The first question asked, "What do you remember as the most important part of your experience in the RDYIF?" Four general themes emerged from 83 responses: receiving advice and feedback, networking with peers, improving presentation skills, and interacting with RDYIF faculty and mentors. The second question asked, "In your view, what impact did participation in the RDYIF have on your career path?" A total of 80 individuals responded to this question. Their answers revealed that although many

participants had already chosen a career as a physician-scientist when they attended the RDYIF, the experience helped to validate or confirm their choice. Other responses described the RDYIF's positive impact on networking skills, scientific communication skills, and confidence. The third question, "Do you have any suggestions for improvement or is there any additional information you would like to provide?", received 49 responses. Most responses reflected a strong desire that the RDYIF be continued. A minority of responses contained suggestions for improvement, which included topics for faculty presentations (e.g., managing personal finances), strengthening the mentoring component of the program, and expanding the program. In aggregate, responses to the open-ended questions

about the RDYIF's impact substantiated the Likert-type ratings of the RDYIF's influence on career development.

DISCUSSION

To our knowledge, this study is the first of its kind to evaluate the impact of an educational symposium designed to identify and prepare outstanding fellows and early-career faculty for physician-scientist careers. Other symposia similar to the RDYIF (7, 18, 19) have aimed to enhance the readiness of young physician investigators for research careers, but the outcomes of these symposia with regard to career achievement and productivity have not been published.

Based on our analysis of survey responses from more than 100 individuals who participated in the RDYIF between 2005 and 2018, the RDYIF was highly successful in strengthening interest in a physician-scientist career. In addition, the RDYIF had a strongly positive impact on the participants' scientific communication skills, ability to build relationships with peers and mentors, and career selection and advancement. There was a lack of a reported positive impact on the transition to independence and factors related to research funding. This result may help guide the development of topics and focus areas for future RDYIFs. The RDYIF was uniformly perceived to be of value and worthy of recommendation to others as a professional development opportunity and resource.

There are many factors that contribute to the development of a successful physician-scientist career, and participation in the RDYIF was certainly not the only experience that influenced individuals who responded to this survey. However, it is worth noting that the majority of the past RDYIF participants who completed the

survey were academic faculty who identified themselves as physician-scientists and spent $\geq 75\%$ of their time on research. In addition, most of these participants had achieved milestones associated with success as a physician-scientist, including an academic faculty position, one or more NIH career research awards, and senior authorship on multiple peer-reviewed publications. A total of 82 survey completers (76.6%) worked as physician-scientists, but an even greater number ($n = 100$ [93.4%]) were in roles involving research, suggesting that many had chosen to stay engaged with research even though they did not perceive themselves to be physician-scientists. The definition presented in the survey described a physician-scientist's research effort as "substantial" and did not specify a percentage of effort, which left room for individual interpretation. The paucity of associate professors and professors among survey completers is likely explained by the fact that 97 years had elapsed between the time when most of the respondents participated in the RDYIF (66.9% participated between 2011 and 2018) and the time of the survey (2019); too little time had passed for them to rise through the ranks to full professor. Another confounding finding from survey completers (45.8% female, 54.2% male) revealed the existence of significantly different ($P < 0.05$) sex differences related to senior and first authorship, and industry awards that favored males. Considering that advances have been made in achieving equality in science, it is intriguing that these findings identify a disparity.

Survey completers were more likely to be involved in clinical research than in basic science or translational research, and the type(s) of research performed did not differ substantially between the more junior

faculty (instructors and assistant professors) and associate professors. Most completers described their primary research area as asthma or chronic obstructive pulmonary disease. The distribution of research areas was likely skewed toward airway diseases because the initial RDYIFs targeted submission of abstracts with an airway or allergic diseases research focus. Later, the focus of the RDYIF expanded to include other areas of respiratory medicine, such as adult and pediatric interstitial lung diseases, pulmonary vascular diseases, sleep, and critical care medicine.

Among survey completers who did not describe themselves as physician-scientists, only 2 of 24 individuals cited concerns about a physician-scientist career having a negative impact on their quality of life as the reason for choosing an alternate career path. Although quality of life *per se* has not been previously studied, the difficulties associated with achieving a comfortable balance between work as a physician-scientist and other life demands have been well described (8, 14, 20).

Consistent with other reports, one of the most common reasons given for pursuing a non-physician-scientist career path was a perceived lack of research funding, adequate mentoring, or institutional support for research. A number of long-term interventions have been recommended to address deficiencies in research funding, mentoring, and institutional support to improve retention in the physician-scientist pipeline (2–6, 10–12). Expanded support for M.D.-Ph.D. programs has also been recommended as a way to increase the population of physician-scientists (3, 12, 21). Studies have shown that the majority of individuals with an M.D.-Ph.D. have gone on to academic research careers (21–23), and that they have been more successful in obtaining NIH R01 awards than those

with an M.D. (2, 3). In our study, a comparison of non-dual degree holders and dual degree holders, which included individuals with any dual degree status, not just an M.D.-Ph.D., showed that dual degree holders had authored more papers, received more grants, and served as a PI in more clinical trials. This distinction was intended to elucidate the impact of additional education on productivity and career development. Conclusions should be drawn cautiously because the subject sample was nonrandom and small in size.

Additional strategies that have been recommended to improve retention in the pipeline have focused on the development of professional skills, including collaboration (15), networking (14), and interactions with role models and mentors (5, 14). Development of a professional identity as a physician-scientist (24) and confidence and clarity in choosing a research career (14) have also been identified as important factors in retention. Based on the results of our survey, participation in the RDYIF may have had the greatest impact by stimulating or confirming participants' interest in a physician-scientist career and by providing opportunities to interact with role models and mentors, and practice networking and scientific communication skills. The importance of good scientific communication skills for the career advancement of individuals with a Ph.D. has been described in the literature (13), but such skills are also essential for physician-scientists.

Several characteristics of this study limit the generalizability of its findings to other populations and educational activities of this type. First, this was an observational study that lacked a control group (individuals who did not apply or who were not selected to participate in the RDYIF). Second, the survey was based on self-reported information from past RDYIF

participants; it was impractical to attempt to verify their responses by obtaining their curricula vitae, publication histories, or funding records. Third, the survey respondents represent only past RDYIF participants whose e-mail addresses could be verified online. It is possible that the e-mail addresses of participants employed in academic medical settings, which often have robust online e-mail directories, were located more often than individuals working in private practice, industry, or government settings. Fourth, as in many online survey studies, the response rate was low (39.3%), despite multiple reminders, which may have skewed the results in a positive direction, as it is possible that those who had a favorable experience were more likely to complete the survey. Thus, nonresponse bias is a major limitation of this study. Although it was beyond the scope of this study, future research could include PubMed and employment searches for all forum participants to evaluate productivity. It is possible that physicians who had experienced success as physician-scientists were more likely to participate in or complete the survey than those in alternate

careers. They may also have been more likely to view the RDYIF in a positive light.

The results of this study support the conclusion that participation in the RDYIF was valuable and had a positive impact on the career development and productivity of fellows and early-career physician faculty performing research in the area of respiratory diseases. Furthermore, we posit that participation in the RDYIF fostered critical, scientific thinking that may have been invaluable for those who focused on clinical practice rather than research careers. Collectively, these findings support the continuation, if not the expansion, of the RDYIF and the development of similar educational events to address the needs of young investigators poised to enter careers as physician-scientists.

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