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Authors

Hurst, Jillian
Barrett, Katherine
Kelly, Matthew
et al.

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Cultivating Research Skills During Clinical Training to Promote Pediatric-Scientist Development

Jillian H. Hurst, PhD,[a,b,c,d] Katherine J. Barrett, MA,[a,c] Matthew S. Kelly, MD, MPH,[a,e] Betty B. Staples, MD,[f] Kathleen A. McGann, MD,[e] Coleen K. Cunningham, MD,[e] Ann M. Reed, MD,[f] Rasheed A. Gbadegesin, MD, MBBS,[a,c,g,h] Sallie R. Permar, MD, PhD[a,c,e,i]

Physician-scientists represent a critical component of the biomedical and health research workforce. However, the proportion of physicians who spend a significant amount of effort on scientific research has declined over the past 40 years. This trend has been particularly noticeable in pediatrics despite recent scientific work revealing that early life influences, exposures, and health status play a significant role in lifelong health and disease. To address this problem, the Duke University Department of Pediatrics developed the Duke Pediatric Research Scholars Program for Physician-Scientist Development (DPRS). The DPRS is focused on research training during pediatric residency and fellowship. We aim to provide sufficient research exposure and support to help scholars develop a research niche and scholarly products as well as identify the career pathways that will enable them to achieve their research goals. Herein, we describe the DPRS's organizational structure, core components, recruitment strategies, and initial results, and we discuss implementation challenges and solutions. Additionally, we detail the program's integration with the department's residency and fellowship training programs (with particular reference to the challenges of integrating research into small- to medium-sized residency programs) and describe the development and integration of related initiatives across Duke University School of Medicine. The program served as the basis for 2 successful National Institutes of Health Stimulating Access to Research in Residency (R38) applications, and we hope it will serve as a model to integrate formalized research training for residents and fellows who wish to pursue research careers in academic medicine.

The past 40 years have seen unprecedented advances in basic, translational, and clinical sciences; data and health informatics; and engineering that have been rapidly translated into advances in patient care. Physician-scientists are individuals who hold MD or DO degrees and spend a significant portion of their professional time conducting scientific research. For the purposes of our discussion, we consider individuals who conduct basic, translational, clinical, and health services research to be physician-scientists.

Because of their unique perspective, which combines scientific inquiry with experiences derived from direct patient care, physician-scientists have the capacity to translate findings from a variety of disciplines into new patient treatment strategies, leading to improved health outcomes. Thus, physician-scientists are critical to the biomedical workforce and continued advances in human health and well-being.

Despite significant research advances, there has been a precipitous decline in

[a]Duke Pediatric Research Scholars Program for Physician-Scientist Development and Divisions of [e]Infectious Diseases and [g]Nephrology, [f]Department of Pediatrics and [b]Clinical and Translational Sciences Institute, [h]Duke Molecular Physiology Institute, [i]Duke Human Vaccine Institute, and [c]Office of Physician-Scientist Development, Duke University, Durham, North Carolina; and [d]Department of Pediatrics, Children's Health and Discovery Institute, Durham, North Carolina

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Address correspondence to Sallie R. Permar, MD, PhD, Duke Human Vaccine Institute, School of Medicine, Duke University, 2 Genome Ct, MSRBII, 103020, Durham, NC 27710. E-mail: sallie.permar@duke.edu

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the number of physicians entering research-focused career paths.[1–5] Physician-scientists were first described as an "endangered species" in 1979,[6] and the trend of decreasing physician participation in biomedical research has continued. The 2014 National Institutes of Health (NIH) Physician-Scientist Workforce Working Group report[7] revealed that <1.5% of physicians considered research to be their primary focus. Moreover, the increasing average age of physician-scientists indicated that fewer physicians were entering research careers, as illustrated by the sharp decline in physician applications for NIH career development (K) awards.[7]

Pediatrics has been particularly affected by the decline in physician-scientists.[8] Although the number of pediatricians practicing in academic medical centers has steadily increased, the proportion of time spent on research activities has remained nearly flat,[9] and subspecialties that have traditionally attracted physician-scientists have become less competitive in recent years.[10] Funding for pediatric research has declined significantly. The proportion of NIH grants awarded to departments of pediatrics declined 7% from 2003 to 2014, and the proportion of the NIH budget committed to pediatric research has remained nearly flat since 2003. Furthermore, success rates for multiple award types sponsored by the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development have declined since 2010.[11,12] In addition to stagnant funding levels for pediatric research, funding awards are concentrated in a relatively small pool of established physician-scientists: 63.6% of R01-equivalent grants were awarded to 15 institutions, and the majority of awardees were men in senior positions.[13] Physician-scientists from a population that is underrepresented in medicine (UriM) are less likely to receive K awards than non-UriM applicants,[14] a trend continuing with R01 funding rates[15] and the general academic physician workforce.[16] Women now account for the majority of pediatric residents (70% in 2017[17]) and subspecialty fellows (68%); however, they are less likely to choose careers as physician-scientists, which further contributes to the decrease in pediatric physician-scientists overall.[18]

The decrease in pediatric physician-scientists and research funding is concerning for the future of pediatric population health. There is growing recognition that many diseases of adulthood have their origins in early life; therefore, there is an urgent need for the development of pediatric-focused biomedical research programs that can elucidate early disease processes and develop preventive and therapeutic strategies to improve lifelong health.[19,20] The Accreditation Council for Graduate Medical Education, the Association of American Medical Colleges, the American Academy of Pediatrics, and the American Board of Pediatrics (ABP) recognize scholarly activities and research as core components of medical training, both in terms of developing the physician-scientist workforce and of training practicing pediatricians to evaluate and implement findings from the medical literature. There is a significant association between early research exposure during residency and pursuit of subspecialty fellowship training that can lead to an academic medical career.[21] However, the American Academy of Pediatrics found in its 2010–2014 Annual Surveys of Graduating Residents that <30% of respondents felt their residency programs prepared them to pursue research.[22] Thus, development of an effective pediatric workforce is dependent on exposure to research activities and an opportunity to improve research exposure and training during residency.

A number of barriers to pediatric physician-scientist development have been cited, including (1) training duration, (2) educational debt,[23] (3) lack of diversity in the physician-scientist workforce,[24] (4) increased clinical duties and/or lack of protected research time, (5) concerns about securing sufficient research funding and decreases in the NIH budget,[25] (6) a lack of mentors for early career investigators,[26,27] and (7) a lack of exposure to and protected time for research during residency and fellowship.[28] Multiple initiatives have been undertaken to address these challenges, including the creation of new career development funding mechanisms targeting both individuals and institutions, loan repayment programs (such as the NIH Loan Repayment Programs, which repay up to $35 000 in qualified debt annually in return for a commitment to NIH mission–relevant research), individualized curricula, and training pathway development (such as the Pediatric Scientist Development Program, a collaboratively funded training pathway for pediatric subspecialty fellows who are committed to research-intensive, academic medical careers).

Mentoring and research exposure during clinical training remain important factors in the decision to pursue a physician-scientist career pathway,[29–32] and impactful physician-scientist training requires programming that can be tailored to the needs of different training environments and trainees. Herein, we describe a physician-scientist training program template and some of the lessons learned through its implementation. The Duke Pediatric Research Scholars Program for Physician-Scientist Development (DPRS) provides career development services and opportunities for trainees in the pediatric residency and subspecialty fellowship programs within the Department of Pediatrics at Duke University. We detail the implementation of this program, focusing on pragmatic solutions and

initiatives that are broadly applicable to pediatric residency and fellowship programs.

PROGRAM DESCRIPTION

The DPRS supports pediatric trainees during the period from completion of their medical degree(s) to residency and fellowship training. The program is broadly designed for trainees interested in pursuing careers in academic general pediatrics or a pediatrics subspecialty. The program supports trainees pursuing a variety of research interests, including basic, translational, clinical, and health services research. The program components described below can be adjusted to accommodate trainees with different research interests and a variety of experience levels.

Research-Integrated Pathways

Depending on their previous research experience and desire to integrate research into their clinical training, pediatric residents may participate in either a categorical training pathway (a standard 3-year residency with up to 2 months of protected research time) or a research-integrated pathway. Since its inception, the DPRS has primarily supported residents and fellows in categorical training pathways; however, we also implemented strategies to increase the number of residents participating in research-integrated pathways.

Currently, a standard categorical pediatric residency training schedule only allows for short research electives, presenting a challenge for initiating and completing enough research to support the development of a scholarly product. In 2000, the ABP approved 2 alternative research-integrated residency pathways, the Integrated Research Pathway (IRP) and the Accelerated Research Pathway, for residents with strong research backgrounds and commitments to academic careers. The IRP is open to residents with a PhD or equivalent research experience and allows for 11 months of protected research time within the second and third year of residency. The Accelerated Research Pathway does not have any specific eligibility criteria and allows for completion of residency training in 2 years, with additional years of research training during a subspecialty fellowship. Each pathway requires at least 1 year of subspecialty fellowship clinical training for board eligibility. These pathways enable research-focused pediatricians in training to maximize the time available for developing a research portfolio that will make them competitive for early career awards and ensure their longevity in a physician-scientist career path.

One limitation to these alternative residency pathways is funding for the protected research time, which typically falls to the department or research mentor. In response to the 2014 NIH Physician-Scientist Workforce Working Group report and recognizing that early research scholarship is an important component of preparation for a physician-scientist career, the NIH initiated the institutional R38 Stimulating Access to Research in Residency (StARR) program in 2017. This training program award allows institutions to propose novel multidepartmental integrated research training programs and provides funding for 12 to 24 months of protected research time for residents. The R38 StARR program is affiliated with an early career award that is open only to R38 training program graduates (K38 Stimulating Access to Research in Residency Transition Scholar). These linked funding mechanisms will provide a stream of continuous research support during residency and fellowship, thereby generating a pathway for resident investigators to transition from being mentored trainees to being independent physician-scientists.

The DPRS and Department of Pediatrics partnered with residency programs in the Departments of Surgery and Medicine to develop a multidepartmental residency training program and, in 2018, received 2 R38 StARR awards, 1 from the National Institute of Allergy and Infectious Diseases and 1 from the National Heart, Lung, and Blood Institute. We worked with the ABP to design a novel integrated research opportunity that includes 18 months of protected research time built into a 4-year residency program that leads to board eligibility at the completion of residency. The grant includes funding for both partial salary support and research expenditures, structured multidepartmental mentoring and didactic training, mentorship for individual career award development, and eligibility for the K38 Stimulating Access to Research in Residency Transition Scholar program. This attractive, research-integrated residency program represents a paradigm shift by creating a framework for supporting research scholarship within a complete clinical training program.

Recruitment

Potential DPRS applicants are selected through both internal and external recruitment events that begin even before the initiation of residency. The Duke University School of Medicine has a unique curriculum that provides students with substantial protected time for research in their third year of school. In collaboration with the Pediatric Residency Program, the DPRS hosts informational sessions for Duke medical students who are interested in pediatric residency training, including students in the Medical Scientist Training Program, and events to help connect medical students with pediatric physician-scientists. Our hope is that this early contact will enhance recruitment of internal candidates, thereby creating a pipeline for the development of pediatric physician-scientists at Duke that spans from medical school to fellowship.

External recruitment of residents through the National Resident Matching Program is coordinated with the Pediatric Residency Program selection committee. Residency applicants who have research backgrounds and express an interest in a physician-scientist career path are invited to Research Scholars Day. This is a half-day program during which applicants meet with potential research mentors and learn about the institutional resources for physician-scientist development and research-integrated training pathways. The Research Scholars Day is followed by a standard residency interview day, and scores and comments from both the research and categorical interviews are considered when evaluating applicants.

As mentioned earlier, those who are UriM are also underrepresented in the community of physician-scientists. To encourage UriM applicants to consider training at Duke, the Duke Office of Graduate Medical Education and Pediatric Residency Training Programs hold a "second-look" weekend, wherein UriM applicants are invited to return to Duke to learn about diversity initiatives and to meet with mentors and current trainees who also identify as UriM. In addition, the DPRS works to pair applicants with interviewers who identify as UriM so that they can hear directly from these individuals about their experience at Duke and their career paths. UriM residents who match into the program are paired with at least 1 mentor who identifies as UriM. Our goal is to foster an environment that values and actively supports the inclusion of all trainees and faculty members, regardless of background.

Applicants who participate in the Research Scholars Day are generally eligible to participate in a research-integrated training pathway such as the IRP or the R38 StARR program. Notably, medium-sized residency programs, such as ours at Duke, can find it challenging to offer integrated training opportunities because of the fine balance of covering clinical needs and completing board-eligibility requirements for each resident. To mediate the challenge of scheduling research-integrated training pathways and to increase the national recognition of the Duke Pediatric Residency Program's commitment to research training, the department opened a separate Electronic Residency Application Service research-pathway residency slot in academic year 2018; a second dedicated research-pathway residency slot was added to the academic year 2019 match. Residents who match into these dedicated research-pathway slots are automatically admitted to the DPRS. Since opening these research-pathway residency slots, the DPRS has matched residency applicants to all available positions. The first resident to matriculate is currently an intern who was accepted into the R38 StARR program; the 2 applicants who recently matched will begin residency in July 2019.

DPRS Application Process

On acceptance into the Pediatric Residency Program or a pediatric subspecialty training program, all residents and fellows are invited to apply to the DPRS. The application consists of an NIH-style biosketch and a 1-page personal statement detailing the applicant's previous research experience, current research interests, and motivation for a career as a physician-scientist. These applications are reviewed by the DPRS directors and scored on past research experience and scholarly output, grants and/or fellowships, and commitment to a research-oriented career. Specific consideration is given to applicants who self-identify as UriM or who are training in small pediatric fellowship programs that do not have substantial dedicated support for research training.

In addition to incoming residents and fellows, the DPRS is also committed to training so-called late bloomers, or individuals who become interested in research a year or more into residency. Each year, the DPRS application is advertised internally to current interns who are eligible to begin the program during the second year of residency. The Pediatric Residency Program supports research for all residents in the form of research elective blocks and funding to disseminate scholarly work; this support is augmented by the DPRS program as described below.

Program Administration

The DPRS program is led by a director and an assistant program director; both are physician-scientists with active research portfolios. The directors are supported by a PhD-level program manager. Additionally, the program is supported by a cadre of experienced pediatric physician-scientists within the department ("super mentors") who commit to serving on scholarship oversight committees (SOCs), assisting with recruitment efforts, and advising scholars at all points along the research path.

The program has a bidirectional relationship with the Office of Pediatric Education, wherein the DPRS Assistant Program Director also serves as the Office of Pediatric Education Associate Director of Physician-Scientist Development and meets regularly with leadership from both groups. This dual role has been critical for the success of the program because it structurally joins the 2 offices by ensuring that the interests of each are represented in all decision-making settings. The DPRS leadership also meets with department division chiefs and fellowship directors to ensure that the program is aligned with subspecialty training program needs. The DPRS leadership is guided by an advisory committee composed of established physician-scientists from within and outside of the department, and provides input in areas such as setting priorities, recruiting scholars, developing program sustainability, and

facilitating communication between the program and the divisions within the department.

Programming and Resources

The DPRS program comprises several elements designed to aid physician-scientist career development (described below).

Concierge-Mentor Identification and Oversight

One of the primary problems in physician-scientist development is a lack of mentors with the experience and resources required to successfully train physician-scientists.[33] Furthermore, the responsibility for training a new physician-scientist cannot rest solely with an individual; instead, mentoring is a team effort that combines the expertise of multiple experienced clinicians and investigators to address the multifaceted aspects of developing a physician-scientist career. To help identify a cadre of experienced mentors for each DPRS scholar, we use a "concierge" approach to mentor identification. DPRS leaders first meet with each scholar to discuss immediate and long-term research goals and program expectations, milestones, and deliverables. Each scholar discusses his or her current arrangements and future needs, including, but not limited to, identifying potential mentors, laboratories (as applicable), other resources they will use to further their research and career goals, and strategies for integrating scholarly activities and clinical responsibilities, all of which are documented in an individualized development plan. Scholars who have not yet identified potential mentors or who are in need of additional mentors are provided with a list of faculty members to meet who might complement their research and career interests. After meeting with these individuals, scholars work with the program manager to determine if any are appropriate mentors or if additional suggestions are needed. This iterative process of mentor identification and regular in-person meetings helps scholars identify mentors on the basis of fit rather than reputation or position, which enhances the research training experience and promotes scholarly productivity. After mentor identification is completed, the program manager continues to work closely with each scholar to review their individualized development plans, aid in developing mentoring relationships, and monitor ongoing progress to address any research challenges they are facing. Regular communication with the program manager builds trust and makes it easier to identify and address any challenges that impede scholars' ability to achieve their goals.

Each DPRS scholar meets regularly with an SOC that consists of the scholar's primary research mentor, a clinical mentor from a subspecialty that the scholar is interested in pursuing, and 1 to 2 additional mentors with expertise related to the scholar's research interest. For residents, the SOC is developed in consultation with DPRS leadership; SOCs for fellows are developed by the relevant subspecialty training program. Once established, each SOC meets with the scholar and DPRS leadership at least twice per academic year to monitor progress, identify areas of need, and address strategies regarding research challenges.

Scholarship Milestones

Previous studies revealed that scholarly output, particularly development of a publication-quality article, is associated with greater satisfaction with residency training and a higher likelihood of subspecialty training.[21,34] Each DPRS scholar is expected to work on scholarly products throughout their time in the program. Clear time lines help residents focus on achievable end points and can be designed to accommodate individual research interests and projects. Scholars are expected to achieve several research milestones in support of their long-term career goals (Table 1), and each programming component is designed to help scholars achieve these milestones.

Seminar Series

The major goals of the seminar series are to provide the scholars with formalized didactics and professional development to enhance progress toward a research career and to help them network with established physician-scientist investigators. This seminar series consists of a 2-year cycle of monthly lectures delivered by faculty members and administrators from the medical school. It covers topics such as study design, research tools and resources available at Duke, data management, the mentor-mentee relationship, regulation of human research, communication skills (including development of grants, articles, and scientific talks), peer review, team science, and analytic and statistical approaches. The seminars are held during the noon conference hour and are scheduled in consultation with the Pediatric Residency Program and chief residents to avoid conflicts with other residency educational programming. Because residents and fellows typically have seminars and conferences scheduled at this time, the clinical services are accustomed to trainees attending educational sessions. Given that patient care responsibilities sometimes preclude trainees from attending seminars, we also record the seminars and post them online for scholars to view at times that work well with their clinical schedules.

Writing Support

Because establishing or augmenting each trainee's scholarly record is the primary goal of the DPRS, scholars receive 1-on-1 assistance in preparing grant proposals, fellowship applications, abstracts, and articles. The program manager also helps identify internal and external funding

TABLE 1 Suggested Milestones

Year	Goals	Deadlines
1	Initial consultation with program directors	September
1	Identify clinical and research mentors	November
1	Outline case report or series, review, or QI research article	December
1	First draft of case report or series, review, or QI research article to mentors	April
1	First SOC meeting[a]	June
2	Submit case report or series, review, or QI research article to peer-reviewed journal	October
2	Present case report or series, research area overview, or QI research to DPRS scholars	December
2	Submit 1–2-page original research plan to mentors and program directors	March
2	Present case report, original research, or QI research at Duke Pediatric Research Day	April
2	Prepare a grant application for an internal or external funding opportunity	Summer
3	Submit a research abstract to a national meeting	Fall
3	Present original research to DPRS scholars	December
3	Submit research article to a peer-reviewed journal	Spring
3	Present original research at a national meeting	Spring

QI, quality improvement.

[a] SOC meetings occur in the fall and spring of years 2 and 3.

opportunities for scholars. These resources help demystify the research, writing, and funding application processes for trainees who otherwise may struggle along the path to becoming independent investigators. For more experienced investigators, they provide opportunities to review their work through fresh eyes. To date, scholars who have accessed these services secured internal (departmental and university-wide) and external funding, such as the Thrasher Early Career Award (an NIH Loan Repayment Program) and professional association grant awards.

Additional Program Resources

Scholars can also access support for professional development and equipment that facilitates research productivity, including funds for travel, publication fees, software licenses, and a laptop computer. Scholars are encouraged to attend local and national meetings to present their work, with the expectation that all program scholars present their research at ≥1 national meeting during their DPRS tenure.

Program Budget

The DPRS is notable for the small size and relative flexibility of its budget. The Duke Department of Pediatrics provides funding for director and associate director stipends, partial salary support for a program manager, and program support for technology resources, publication fees, and conference travel (described above). Notably, the budget scales with program size, making such a program achievable for small- to medium-sized training programs. A sample nonpersonnel budget is provided in Table 2.

Building a Physician-Scientist Community

One of the greatest benefits of a physician-scientist training program is helping trainees build their professional research network. The DPRS program connects scholars with world-renowned investigators across Duke University, and these investigators often embed DPRS scholars within their research groups. Additionally, DPRS-sponsored seminars and workshops and support from the program manager are made available to all pediatrics residents, fellows, and faculty members to spread interest and increase participation in research across the department. To help facilitate connections across the Duke University School of Medicine, DPRS cosponsors a yearly physician-scientist symposium, which features speakers from all career and training levels, and provides a venue to share information about schoolwide initiatives and resources. We also expect that the camaraderie built through the DPRS itself will carry forward as scholars move into academic appointments across the nation.

PROGRAM IMPACT

Because the primary goal of the DPRS is to help scholars establish themselves as physician-scientists, metrics of success are focused on scholarly productivity (Table 3). Thus far, we have had 2 cohorts of scholars, with each group of scholars starting at the beginning of the academic year. In Table 4, we provide a description of the research conducted by residents and fellows. As of May 2019, 29 DPRS scholars have had 45 presentations at national, regional, and local conferences, including 8 platform presentations. Scholars also obtained 14 research grants and training fellowships and have published 24 articles in peer-reviewed journals. DPRS mentors and leadership celebrate these achievements with the scholars, acknowledging the unique challenges each individual overcame along the way. Because the program is young, it

TABLE 2 Sample Nonpersonnel Budget

Budget, $	Category	Description
9000	Computers and software	Laptops or software is provided to incoming scholars
9000	Domestic travel	Up to $1500 per scholar; average 6 per y
750	Printing and office supplies	Recruitment materials
5000	Publications	Fees for open access (on a first come, first served basis)
1800	Recruitment catering	Lunches, wine, and cheese for 4 recruitment events
25 550	Total	

Excludes general and administrative expenses, space, and any other organization-mandated expenditures.

is difficult to determine its long-term career impact; however, we are actively tracking a variety of metrics to evaluate research productivity for physician-scientist trainees across the Duke University School of Medicine, which will aid in future evaluation. Notably, the DPRS program template has been expanded across Duke University School of Medicine, which recently created the Office of Physician-Scientist Development, led by S.R.P., the corresponding author of this report.

TABLE 4 Types of Research Conducted by DPRS Program Scholars

Training Level and Type of Research	Areas of Research
Resident	
Basic	Immunology
	Neurology
	Oncology
Clinical	Cardiology
	Global health
	Health disparities
	Health care use
	Immunology
	Nephrology
	Patient education
	Virology
Translational	Metabolism
Fellow	
Basic	Genetics
	Genomics
	Immunology
	Microbiome
	Neonatology
	Virology
Clinical	Cardiology
	Neonatology
	Oncology
	Virology
Translational	Critical care
	Nephrology

FUTURE DIRECTIONS

Although the importance of support for pediatrician-scientists has been formally identified as an area of need, the lack of institutional and national support for research career–pathway training has already reduced the pipeline of research-focused trainees. Notably, the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development task force recommended rebalancing their training and career development programs to reduce the emphasis on institutional training programs (T32s and K12s) in favor of individual awards.[31] An untoward risk of this trend is a lack of discovery and clinical research into novel disease prevention and therapeutics. Given the increasing complexity and burden of pediatric health issues, the lack of pediatric physician-scientists will continue to have a negative impact on population health. It is imperative to implement training opportunities that integrate clinical and research training. Programs such as the NIH R38 StARR awards signal that we are at the precipice of this change; however, there are still gaps in the training continuum that must be addressed to ensure a pipeline of pediatricians who can lead the development of novel preventive and therapeutic modalities as well as ensure excellent care of pediatric patients. Residency and fellowship programs can help fill some of these gaps by building department-level programs that augment clinical training with integrated research training. This DPRS approach is 1 example of how departments might design and implement this type of research curriculum. The next generation of pediatric physician-scientists and their patients are counting on current leaders in pediatric research and education to create and implement novel clinician-investigator pathways that they will then transcend.

TABLE 3 Scholarly Output, August 2017–April 2019

Scholarly Product	Residents, *n*	Fellows, *n*
Peer-reviewed articles		
Published	13	8
Accepted	4	1
In review	2	4
Conference and/or meeting abstracts[a]		
Podium	3	6
Poster	19	17
Grant and fellowship awards	8	6

[a] Includes national and regional conferences.

ABBREVIATIONS

ABP: American Board of Pediatrics
DPRS: Duke Pediatric Research Scholars Program for Physician-Scientist Development
IRP: Integrated Research Pathway
NIH: National Institutes of Health
SOC: scholarship oversight committee
StARR: Stimulating Access to Research in Residency
UriM: underrepresented in medicine

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