Pediatric RESEARCH

www.nature.com/pr

POPULATION STUDY ARTICLE

Engagement in research among pediatric subspecialists at the time of enrollment in maintenance of certification, 2009–2016

Michelle L. Macy[1,2], Kenton Derek Van[3], Laurel K. Leslie[4,5] and Gary L. Freed[3,6,7]

BACKGROUND: Amid concerns about the pediatrician-scientist workforce, we hypothesized that declining numbers of pediatric subspecialists devote at least 25% of their professional time to research with fewer younger and female pediatricians engaged in research over the study period.

METHODS: Board-certified pediatricians enrolling online in the American Board of Pediatrics (ABP's) Maintenance of Certification (MOC) program October 2009 through 2016 were invited to complete a survey with questions about the allocation of their professional time. Responses from individuals in the 14 ABP-certified subspecialties were analyzed. The number and proportions of respondents devoting 25–49% and 50% or more of professional time to research were calculated over time. Age and gender were also examined.

RESULTS: We analyzed 21,367 responses over 8 years. A small number of pediatric subspecialists engaged in research with 5.2–6.7% devoting 25–49% and 5.6–8.4% at least 50% of their professional time to research across subspecialties. There was no discernable increase or decrease over time or pattern by age or gender.

CONCLUSION: Less than 10% of pediatric medical subspecialists devote at least 50% of their professional time to research. Efforts to promote research among pediatric subspecialists have not increased the size of the population that reports engaging in research at this level.

Pediatric Research _####################_; https://doi.org/10.1038/s41390-019-0703-2

INTRODUCTION

Numerous published commentaries and opinion pieces decry a dwindling number of physician-scientists in the United States over the past generation.[1–8] Concerns about declining funding and increased competition for awards from the National Institutes of Health (NIH) have been cited as factors driving investigators to leave academic careers.[9,10] The population of researchers with R01 funding is aging[11] and NIH-funded physician-scientists are estimated to represent less than 1.5% of the total physician workforce.[12] Fears about the loss of a generation of physician-scientists have generated interest in the potential role of industry, public–private partnerships, and professional societies to train and support young biomedical researchers.[9,10,13,14]

Specific concerns have been raised about declining numbers of pediatricians who choose to focus their careers on research,[1] decreasing rates of NIH grant awards to pediatric departments,[1,15] and the impact of these trends on the creation of new knowledge and scientific innovation to improve child health.[1,8] Pediatric physician-scientists are often trained in medical subspecialties through pathways that traditionally require 3 years of pediatric residency and 3 or more years of fellowship. Within pediatric medical subspecialty fellowships certified by the American Board of Pediatrics (ABP), trainees receive a formal introduction to research with a goal of mastery through the completion of fellowship. Even though few subspecialty fellowship graduates are anticipated to have a career focus in research, they can be expected to achieve sufficient skills to collaborate productively in team science.[15]

There have been several approaches put forward over time to patch the "pipeline" of pediatric physician-scientists and new "on ramps" to research careers are being considered. The ABP has created two infrequently utilized alternative pathways to expedite clinical training and increase research exposure, the integrated pathway and the accelerated pathway.[3] Building on the ABP's integrated pathway framework, there are a few structured Pediatrician Scientist Training and Development Programs that have published on their approach and experience.[16–18] In addition, pediatric-focused T32 training programs and K12 awards, such as the Pediatric Scientist Development Program (PSDP) sponsored by the Association of Medical School Pediatric Department Chairs and funded by the National Institutes of Child Health and Human Development and private agencies, have been successful in the development of fellows and faculty who intend to make research their primary professional activity.[19–21]

Despite the expressed concerns, there is a paucity of research on the physicians within the pediatric subspecialty workforce by their level of engagement in research. To address this gap, we analyzed data collected by the ABP at the time of enrollment into Maintenance of Certification to understand trends in the number and proportion of pediatric subspecialists who report devoting

[1]Department of Pediatrics, Feinberg School of Medicine, Northwestern University, Chicago, IL, USA; [2]Division of Emergency Medicine, Ann & Robert H. Lurie Children's Hospital of Chicago, Chicago, IL, USA; [3]Susan B. Meister Child Health Evaluation and Research (CHEAR) Center, University of Michigan, Ann Arbor, MI, USA; [4]American Board of Pediatrics, Chapel Hill, NC, USA; [5]Tufts Medical Center/School of Medicine, Boston, MA, USA; [6]Division of General Pediatrics, Department of Pediatrics, University of Michigan, Ann Arbor, MI, USA and [7]Department of Health Management and Policy, School of Public Health, University of Michigan, Ann Arbor, MI, USA
Correspondence: Michelle L. Macy (mmacy@luriechildrens.org)

Received: 25 July 2019 Revised: 14 November 2019 Accepted: 19 November 2019
Published online: 30 November 2019

25−49% or at least 50% of their professional time to research. We hypothesized there would be declines over time in the proportion of pediatricians devoting at least 25% of their professional time to research and that there would be fewer pediatricians younger than 50 years old and fewer female pediatricians engaged in research at this level.

METHODS

Context

The ABP's Maintenance of Certification (MOC) program emerged in 2003, building off of earlier models of recertification that focuses primarily on a periodic re-examination of knowledge. The program has gone through several iterations since that time, resulting in changes to both the examination and MOC cycle lengths. The number of pediatricians enrolling in MOC in a given year is dependent upon several factors. First, there is variation in the number of subspecialists within a given field. Second, the initial certification examinations for pediatric subspecialties are offered every other year, some in odd and some in even years. Some subspecialties have recently changed their every 2-year timeframes. Third, some pediatric subspecialists maintain dual certification in general pediatrics and their examination and MOC cycles may thus be linked to their general pediatrics certification dates. Fourth, the MOC cycle changed from 7 years to 5 years for MOC enrollees in 2010; there has also been an evolution of the duration of examination cycles, ranging from 5 to 10 years, over the past 20 years.

Subjects

Board-certified pediatricians enrolling online in the ABP's Maintenance of Certification (MOC) program October 2009 through 2016 were provided with the opportunity to complete a brief survey at the time of registration. There were technical issues in 2012 with the survey administration for some individuals and a special invitation to complete the survey was distributed. Completion of the survey was not tied to reports of completed MOC activities or receipt of MOC credit.

We included responses from board-certified pediatricians enrolling in their first and subsequent MOC cycles in analyses as we were interested in understanding cross-sectional trends. We focused our analysis on survey responses from pediatric subspecialists who were practicing in one of the 14 ABP-certified subspecialties at the time of survey administration: Adolescent Medicine, Cardiology, Child Abuse, Critical Care, Developmental Behavioral, Emergency Medicine, Endocrinology, Gastroenterology, Hematology Oncology, Infectious Diseases, Neonatology, Nephrology, Pulmonology, and Rheumatology.

We excluded respondents who indicated their practice was exclusively in a subspecialty that is sponsored by another board of the American Board of Medical Specialties because we do not have a mechanism for obtaining demographic characteristics of these individuals. These subspecialties included Neurodevelopmental Disabilities, Congenital Heart Disease in Adults, Hospice and Palliative, Medical Toxicology, Sleep, Sports, Transplant Hepatology, Immunology, and Genetics. However, if an individual was dually boarded for example, in Pulmonary and Sleep, they would be eligible for this study as they would have had the opportunity to complete the survey offered at enrollment in MOC for their ABP certification in Pulmonary. Pediatric Hospital Medicine was not included because the certifying examination was not offered by the ABP during the study period. The first Pediatric Hospital Medicine examination was offered in 2019.

Measures

De-identified data from the MOC surveys as well as demographic characteristics of the respondents were obtained from the ABP's Certification Management System and transmitted from the ABP to the research team at the University of Michigan Child Health Evaluation and Research (CHEAR) Center in Microsoft Excel (Microsoft, Inc., Redmond, WA) format for analysis. The University of Michigan Committee for the Protection of Human Subjects (IRBMED) approved the project.

In each survey, respondents were asked to indicate the current proportion of their total professional time spent performing each of the following tasks: patient care, administration, research, medical education, and other. The respondent interpreted these categories in their individual context within their institution or practice. We categorized respondents based on the proportion of professional time devoted to research into three groups, Group 1—little research effort: <25%, Group 2—some research effort: 25−49%, and Group 3—substantial research effort: 50% or more. We selected 25% for the lower cut point as this represents more than 1 day per week is spent in research. In some academic settings, 1 day per week of protected time may be afforded to junior faculty who are pursuing external funding. We selected 50% or more for the upper cut point as this represents individuals with careers dedicated primarily to research. These individuals are expected to engage in securing grants or other funding mechanisms to support at least half of their professional effort in research. This threshold also captures federal K-series and other career development awards that can require as much as 75% of a physician-scientist's effort toward research. Age and gender were the demographic characteristics available for analysis in this study. We examined age categorically in terms of career stage given the small number of individuals in some fields. We considered pediatricians who were younger than 50 years old as early to mid-career and pediatricians 50 years old or older as later career.

Analysis

We calculated descriptive statistics including counts and proportions by time devoted to research overall and within each subspecialty. For additional context, we compiled information on the number of MOC survey responses over the 8-year study period relative to the pediatric subspecialists within each field with a certificate status of "time-limited/no end date" (i.e., enrolled in MOC) at the end of 2017.[2] We also compared, by gender and by career stage (early to mid and later), the number and proportion of pediatric subspecialists reporting research effort of at least 25%.

RESULTS

Over the 8-year study period, a total of 56,719 MOC surveys were completed. Our analyses focused on the 21,367 responses from pediatric subspecialists who identified as practicing in one of the 14 ABP-certified pediatric medical subspecialties. Subspecialists represented 37.7% of the total MOC survey respondents. There was variation in the number of responses per year ranging from a low of 5981 in 2009 to a high of 11,924 in 2015, reflective of the variation in the number of individuals who enrolled in MOC in a given year. The response rate per survey year ranged from 71.0 to 89.8%, except for 2012, which had a response rate of 96.3%. In 2012, the ABP responded to technical difficulties with the distribution at the time of MOC enrollment by sending a special invitation to complete the survey due to those who were impacted. The gender, age category, and subspecialty of respondents in each year are presented in Table 1. In all years but 2016, there were consistently more male than female respondents. Year to year we observed variation in the number and proportion of responses by age group and across subspecialties.

The ratio of MOC enrollment survey responses to total subspecialists in MOC ranged from a low of 0.80 for Hematology to a high of 1.81 for Adolescent Medicine (Table 2). More respondents from the fields with ratios less than one (Hematology Oncology (0.80), Cardiology (0.82), Gastroenterology (0.86),

Table 1. Demographic characteristics of subspecialty respondents over the study period.

Year		2009	2010	2011	2012	2013	2014	2015	2016
Total		2711	2661	2377	2043	1599	3015	3720	3240
		% (*n*)	% (*n*)	% (*n*)	% (*n*)	% (*n*)	% (*n*)	% (*n*)	% (*n*)
Gender	Female	44.0 (1192)	46.3 (1231)	47.2 (1123)	47.5 (955)	44.3 (708)	43.4 (1310)	48.7 (1813)	55.8 (1807)
	Male	56.0 (1519)	53.7 (1430)	52.8 (1254)	54.1 (1088)	55.7 (891)	56.6 (1705)	51.3 (1907)	44.2 (1433)
Age[a]	<50 years	56.4 (1530)	56.2 (1496)	59.8 (1422)	47.4 (954)	42.7 (683)	36.7 (1108)	52.0 (1933)	63.8 (2066)
	≥50 years	43.6 (1181)	43.8 (1165)	40.2 (955)	54.2 (1089)	57.3 (916)	63.3 (1907)	48.0 (1786)	36.2 (1174)
Subspecialty	Adolescent Medicine	2.8 (75)	5.0 (132)	6.2 (148)	4.8 (96)	3.4 (54)	2.2 (67)	4.4 (165)	3.3 (107)
	Cardiology	10.6 (288)	8.0 (213)	7.2 (171)	11.7 (236)	10.0 (160)	10.0 (303)	10.6 (396)	7.9 (255)
	Child Abuse	1.4 (37)	2.5 (66)	1.9 (45)	2.6 (53)	2.3 (36)	1.8 (54)	1.7 (64)	3.2 (104)
	Critical Care	12.7 (345)	9.4 (249)	13.1 (311)	8.9 (179)	8.4 (135)	10.2 (308)	11.4 (425)	9.5 (309)
	Developmental Behavioral	11.2 (303)	3.9 (105)	4.8 (115)	4.3 (87)	4.1 (66)	8.9 (267)	3.0 (111)	5.1 (166)
	Emergency Medicine	11.2 (303)	15.7 (417)	13.6 (323)	11.4 (230)	17.4 (278)	10.3 (312)	12.6 (469)	14.9 (484)
	Endocrinology	4.8 (131)	3.8 (144)	3.8 (91)	5.3 (107)	5.6 (90)	5.4 (163)	4.1 (154)	7.3 (237)
	Gastroenterology	5.8 (158)	4.7 (125)	8.6 (205)	4.3 (87)	8.3 (132)	5.5 (167)	4.4 (163)	9.0 (292)
	Hematology-Oncology	6.8 (183)	9.8 (189)	9.8 (233)	6.5 (130)	8.1 (130)	7.0 (211)	6.0 (222)	11.5 (374)
	Infectious Diseases	3.1 (83)	5.4 (144)	6.6 (158)	5.6 (113)	4.8 (77)	3.0 (90)	6.4 (238)	5.9 (191)
	Neonatology	19.8 (536)	23.8 (632)	17.4 (413)	26.4 (531)	16.1 (258)	26.9 (812)	25.7 (957)	14.2 (459)
	Nephrology	2.6 (70)	1.8 (48)	1.9 (44)	2.5 (50)	2.6 (41)	2.6 (77)	2.6 (96)	1.9 (61)
	Pulmonology	6.4 (173)	6.2 (164)	3.5 (83)	4.3 (86)	6.3 (100)	5.0 (152)	5.8 (217)	3.7 (120)
	Rheumatology	1.0 (26)	1.2 (33)	1.6 (37)	1.3 (26)	2.6 (42)	1.1 (32)	1.2 (43)	2.5 (81)

[a]Age was missing for one individual in 2015

Endocrinology (0.88), Infectious Diseases (0.90), Rheumatology (0.90), and Nephrology (0.91)) reported devoting at least 25% of their professional time to research than respondents from fields with ratios greater than one (Pulmonology (1.11), Neonatology (1.16), Emergency Medicine (1.32), Child Abuse (1.38), Developmental Behavioral (1.80), and Adolescent Medicine (1.81)). Critical care had a ratio of 1.01.

In Table 3, we present the proportion of respondents by their self-reported professional time devoted to research (categorically in three groups: <25%, 25–49%, ≥50%) for each subspecialty in each year. Over the study period, Child Abuse had the lowest engagement in research. There were several years where no Child Abuse subspecialists reported devoting even 25% of their professional time to research. The fields of Hematology Oncology and Infectious Diseases showed the greatest numbers and highest proportions of respondents reporting at least 25% of their professional time was devoted to research. While there were variations (year to year within subspecialty and across subspecialties within a given year), there was no discernable pattern of decline or increase in the pediatric subspecialty workforce self-reporting they devoted 25−49% or at least 50% of their professional time to research over the study period.

For all subspecialists the proportions of male and female respondents who reported devoting at least 25% of their professional time to research were relatively consistent over the study period but there were some subspecialties in which one gender was predominant. In the fields of Adolescent Medicine, Developmental Behavioral, Endocrinology, and Rheumatology, the proportion of female researchers was predominant. In the fields of Cardiology, Critical Care, Gastroenterology, Hematology Oncology, Nephrology, and Pulmonology, the proportion of male researchers was predominant. The fields of Child Abuse, Emergency Medicine, Infectious Diseases, and Neonatology had more even gender balance.

Overall and within most years for most subspecialties, the respondents who reported devoting at least 25% of their professional time to research were predominantly <50 years old (early to mid-career). There were higher proportions of later career researchers within the fields of Pulmonology (in several years), Gastroenterology, Neonatology and Rheumatology (in 2 years). Although there was a decline in the proportions of early to mid-career pediatric rheumatologists and nephrologists devoting at least 25% of their professional time to research over most of the study period, higher proportions were observed in the most recent 2 years of data.

DISCUSSION

The number and proportion of pediatric subspecialists who devote at least 25% of their professional time to research is small but has remained relatively consistent over the past 8 years. Our findings suggest that efforts to bolster the pediatrician scientist workforce[16–18,21,22] may be falling short given the increased number of subspecialists overall and in the face of increased focus on clinical effort in many academic centers. The overall number of individuals across all subspecialties who reported dedicating significant professional effort to research ranged from 105 to 259 per year throughout the study. In most pediatric subspecialties, fewer than 20 individuals per year reported engaging in research for 50% or more of their professional time. However, it is important to highlight that pediatrician subspecialists with at least 50% of their professional time in research are primarily concentrated in a small number of fields that have historically ranked highly in successful funding for pediatric R01-equivalent awards.[23]

We observed variation in the ratios of the total MOC enrollment survey responses to total subspecialists holding certificates in MOC status. A ratio greater than one reflects specialties where individuals provided survey responses in two different MOC cycles during the study period. On the other hand, ratios less than one are indicative of subspecialties where a proportion of individuals in the field did not enroll into a new MOC cycle during the years of

Table 2. Characteristics of certification cycles and maintenance of certification among pediatric subspecialties certified by the American Board of Pediatrics.

Subspecialty (year the certificate was first offered)	Cycle for initial certification	Total MOC enrollment surveys completed 2009–2016	Total subspecialists, age 70 and under, in MOC[a] as of December 31, 2017	Ratio of MOC survey responses: total subspecialist in MOC
Adolescent Medicine (1994)	Odd years, until 2008	844	467	1.81
Cardiology (1961)	Even years	1821	2212	0.82
Child Abuse (2009)	Odd years	459	333	1.38
Critical Care (1987)	Even years	2261	2234	1.01
Developmental Behavioral (2002)	Even years, until 2009	1220	677	1.80
Emergency Medicine (1992)	Even years, until 2009	2816	2138	1.32
Endocrinology (1978)	Odd years	1117	1265	0.88
Gastroenterology (1990)	Odd years	1329	1539	0.86
Hematology-Oncology (1974)	Even years, until 2009	1672	2079	0.80
Infectious Diseases (1994)	Odd years	1094	1219	0.90
Neonatology (1975)	Odd years, until 2008	4598	3958	1.16
Nephrology (1974)	Odd years, until 2008	487	535	0.91
Pulmonology (1986)	Even years	1095	989	1.11
Rheumatology (1992)	Even years, until 2009	320	357	0.90

[a]With a time-limited/no end date certificate status

our study or did not choose to complete the survey. Several factors likely contribute to this finding, which relates to the timing of an individual's enrollment in MOC. First, subspecialty board certification examinations are offered in alternating years and some specialties shifted from odd to even years, or vice versa, in the 7 years prior to this study. Second, there have been changes in duration of recertification and MOC cycles over the past two decades. Third, some individuals may maintain board certification in general pediatrics and their subspecialty. Regardless, our approach allows us to understand cross-sectional trends in the number and proportion of pediatric subspecialists who reported devoting 25–49% or at least 50% of their professional time to research at the time of enrollment in MOC.

The proportion of females and early to mid-career individuals younger than 50 years who are devoting at least 25% of their professional time to research was consistent over the study period. This finding may signal that new investigators are entering the pediatric subspecialty workforce with some commitment to research. However, with <1.5% of the total physician workforce engaged in NIH-funded research[24] and a plateau in the annual growth rate of pediatric spending by the NIH,[25,26] we hypothesize that pediatric subspecialists are receiving research support mechanisms other than the NIH. In the era of team science, those with 25−49% of their professional time devoted to research may be taking on roles as site principal investigators in multicenter, federal studies or industry-sponsored trials. This hypothesis is grounded in the notion that the landscape of research has changed dramatically since the 1960s when NIH funding was awarded to more than 40% of new R01 applicants. In the period from 2010 to 2015, the success rate for NICHD K08 awards decreased from 56 to 14%, K23 awards from 40 to 18%, and R01 awards decreased from 17 to 12%.[26] Further, the scope of pediatric research has expanded beyond laboratory science to include clinical, health services, translational, and quality improvement. Additionally, there have been calls for expanding funding collaborations between academic medical centers and corporations, foundations, and medical societies.[9,10] As these changes have taken place, new sources of funding outside of the NIH have provided support to investigators who frequently work in larger teams.[11]

The small number of early to mid-career pediatric subspecialists (<50 years) who are dedicating 50% or more of their professional time to research may have protected time to complete formal research training and career development awards, such as T32, F32, K awards, including the PSDP K12 programs, or other sources of support (e.g., Clinical Translational Science Awards, industry training partnerships). These individuals are critical to fill the pipeline as pediatrician scientists retire or take on other roles and responsibilities later in their careers. Good et al. found as many as 24% of pediatric physician-scientists holding R01-equvalent awards also hold chief, chair, or dean positions.[23] Investment into training pathways is important to the pipeline as individuals who complete dedicated research fellowship and independent career development awards with or without institutional career development awards are more likely to receive R01 funding in the future.[20,27] However, more support and high-quality training may be needed as success rates in moving from career development awards to longer-term funding remain challenging.[28] Although the number of new NIH R01 grants submitted by MDs overall was stable over the past four decades and increased for MD/PhDs, the percentage of R01 grants awarded declined from 1964 to the mid-1980s and has hovered around 30% since.[24] Success in obtaining funding has remained lower for MDs compared with MD/PhDs and PhDs over time.[24]

Targeting institutional investments toward the development of fellows and faculty who have a passion for research and who

Table 3. Number and proportion* of respondents within each subspecialty by categorical percentage of professional time devoted to research per year of enrollment in MOC.

Subspecialty	Percent of professional time in research	2009 % (*n*)	2010 % (*n*)	2011 % (*n*)	2012 % (*n*)	2013 % (*n*)	2014 % (*n*)	2015 % (*n*)	2016 % (*n*)
Adolescent Medicine	Total *n*	75	132	148	96	54	67	165	107
	<25%	93.3	98.4	90.5	90.6	94.4	91	89.7	91.6
	25–49%	4	7.6	4.1	5.2	0	4.5	4.8	3.7
	≥50%	2.7	3	5.4	4.2	5.6	4.5	5.5	4.7
Cardiology	Total *n*	288	213	171	236	160	303	396	255
	<25%	92	88.3	90.6	94.9	88.7	94	91.4	91
	25–49%	3.8	7	4.1	3	7.5	3	4	5.1
	≥50%	4.2	4.7	5.3	2.1	3.8	3	4.5	3.9
Child Abuse	Total *n*	37	66	45	53	36	54	64	104
	<25%	100	100	100	98.1	94.4	98.1	96.8	97.1
	25–49%	0	0	0	0	0	2.9	1.6	0
	≥50%	0	0	0	1.9	5.6	0	1.6	2.9
Critical Care	Total *n*	345	249	311	179	135	308	425	309
	<25%	88.7	86.7	83	83.8	91.1	90.9	88.5	87.7
	25–49%	5.5	8.4	8.3	10	4.4	3.9	6.3	6.8
	≥50%	5.8	4.8	8.7	6.1	4.4	5.2	5.2	5.5
Developmental Behavioral	Total *n*	303	105	115	87	66	267	111	166
	<25%	90.5	93.3	93.9	96.6	95.5	92.1	92.8	93.4
	25–49%	5.9	1.9	4.3	2.3	0	5.6	3.6	5.4
	≥50%	3.6	4.8	1.7	1.1	4.5	2.2	3.6	1.2
Emergency Medicine	Total *n*	303	417	323	230	278	312	469	484
	<25%	91.1	96.2	94.7	95.2	93.9	96.1	95.5	95.7
	25–49%	6.6	2.1	3.4	3.5	4.3	2.9	3.4	2.7
	≥50%	2.3	1.7	1.9	1.3	1.8	1.0	1.1	1.6
Endocrinology	Total *n*	131	144	91	107	90	163	154	237
	<25%	79.4	75	79.1	85.1	83.3	81.6	80.5	87.3
	25–49%	10.7	8.3	7.7	6.5	4.4	5.5	6.5	6.8
	≥50%	9.9	16.7	13.2	8.4	12.2	12.9	13	5.9
Gastroenterology	Total *n*	158	125	205	87	132	167	163	292
	<25%	89.9	83.2	84.9	86.2	93.9	91.6	87.1	88
	25–49%	5.1	5.6	7.8	5.7	1.5	3	5.5	6.2
	≥50%	5.1	11.2	7.3	8	4.5	5.4	7.4	5.8
Hematology-Oncology	Total *n*	183	189	233	130	130	211	222	374
	<25%	57.4	69.3	69.1	63.8	60.8	65.4	68.9	66
	25–49%	13.1	15.3	10.7	18.5	15.4	12.3	14.9	12.8
	≥50%	29.5	15.3	20.2	17.7	23.8	22.3	16.2	21.1
Infectious Diseases	Total *n*	83	144	158	113	77	90	238	191
	<25%	69.9	61.8	68.4	65.5	77.9	74.4	64.3	69.6
	25–49%	14.4	15.3	11.4	8	7.8	8.9	14.3	7.9
	≥50%	15.7	22.9	20.2	26.5	14.3	16.7	21.4	22.5
Neonatology	Total *n*	536	632	413	531	258	812	957	459
	<25%	90.1	89.1	91.3	91.7	92.6	92.4	91.1	93
	25–49%	5.4	4.9	4.1	4.5	5.4	4.8	3.9	3.9
	≥50%	4.5	6	4.6	3.8	1.9	2.8	5	3.1
Nephrology	Total *n*	70	48	44	50	41	77	96	61
	<25%	81.4	75	79.5	78	87.8	84.4	83.3	82
	25–49%	11.4	12.5	4.5	10	7.3	13.0	5.2	9.8
	≥50%	7.1	12.5	15.9	12	4.9	2.6	11.5	8.2
Pulmonology	Total *n*	173	164	83	86	100	152	217	120
	<25%	86.1	82.3	84.3	88.4	87	87.5	82.9	81.7
	25–49%	6.4	6.7	6	4.6	3	5.9	7.4	10.8

Table 3 continued

Subspecialty	Percent of professional time in research	2009 % (*n*)	2010 % (*n*)	2011 % (*n*)	2012 % (*n*)	2013 % (*n*)	2014 % (*n*)	2015 % (*n*)	2016 % (*n*)
	≥50%	7.5	12	9.6	7	10	6.6	9.7	7.5
Rheumatology	Total *n*	26	33	37	26	42	32	43	81
	<25%	69.2	66.7	73	84.6	81	81.2	93	74.1
	25–49%	7.7	15.1	8.1	0	9.5	6.3	4.7	8.6
	≥50%	23.1	18.2	18.9	15.4	9.5	12.5	2.3	17.3
All subspecialties	Total *n*	2711	2661	2377	2011	1599	3015	3720	3240
	<25%	86.5	85.5	85.4	87.7	88	89.2	87.2	86.4
	25–49%	6.6	6.8	6.2	5.9	5.4	5.2	5.9	6.2
	≥50%	6.9	7.7	8.4	6.5	6.6	5.6	6.9	7.4

*Some percentages do not total 100 due to rounding

intend to make research their primary professional activity may yield a stronger pediatric physician-scientist workforce than efforts to encourage broadly individuals to initiate research careers to increase overall numbers. There are a few programs that have recently published on their approaches to promote research among pediatric trainees. A novel curriculum to foster pediatrician-scientists has been implemented at Baylor College of Medicine and Texas Children's Hospital[16] provides one example of a program that has increased the number of applicants and matriculating residents on research career paths in a single institution.[17] The Duke Pediatric Research Scholars Program for Physician-Scientist Development (DPRS) provides another model for integrating research into a department's residency and fellowship training programs with demonstrated success in research presentations, grant support, and publication among scholars who participate in a program that offers careful selection of mentors, set scholarship milestones, writing support, and community building.[18] Lastly, the PSDP currently provides 100% protected laboratory-based research time to 5−6 scholars each year for 2−3 years in order to bridge the critical period of postdoctoral research training in the career development of pediatric physician-scientists.[21] However, it is unclear if programs such as these are creating new interest in research among those entering pediatric residency or are attracting those already predisposed to research careers.

Our findings are subject to the following limitations. First, as with any voluntary survey, our results may be subject to response bias. We have no data on the pediatric subspecialists who do not participate in MOC. We suspect our results would overestimate engagement in research if individuals who are enrolling in MOC are from academic medical centers where research is a focus. However, the distribution of our respondents across the 14 ABP-certified medical subspecialties closely matches the distribution of newly board-certified pediatricians within each of these subspecialties as reported in the ABP Workforce Data Book[29] and the ABP's Interactive Workforce website.[30] Second, some individuals may be represented twice in the dataset as our analysis spans 8 years (2009–2016) and there was a 5- or 7-year cycle length for MOC during this time. Conversely, the focus on currently certified pediatricians in the 14 ABP-certified medical subspecialties has potential to underestimate the population of scientists, including those with PhDs and those MDs who no longer maintain board certification, who are conducting research relevant to pediatric populations. Within the field of pediatrics, 57% of R01-equivalent grants for pediatric research from 2012 to 2017 were awarded to individuals with a medical degree with or without an additional graduate degree.[23] Therefore, analyses of physician engagement in pediatric research do not capture the entire scope of research being conducted to improve the health and wellbeing of children. Third, we do not have a mechanism to verify the true percent research effort for any respondent, but we do not have reason to suspect pediatricians would systematically over or under report their effort in research. Fourth, we have no information about the sources of funding that support pediatric subspecialists who are engaged in research. This prevents our ability to assess for shifts over time in external funding for research among pediatric subspecialists. It is possible that some survey respondents considered only externally funded research in their percent effort calculations while others may have included internally funded or unfunded projects. Additionally, pediatricians who contribute to team science by serving as co-investigators on studies or those serving as site PIs on industry-sponsored trials may not accrue 25% effort on research studies. These individuals would not be considered devoting substantial professional time to research by our study definitions but are still making contributions to the generation of new knowledge in pediatric medical care. Fifth, we do not have information on other demographic characteristics such as location of practice (children's hospital, University, or community) or the race/ethnicity of respondents to the MOC surveys. Lastly, we do not have a measure of success or productivity of the individuals who devote 25–49% or at least 50% of their time to research or if different individuals move in and out of these categories over time.

ACKNOWLEDGEMENTS

This study was funded by the American Board of Pediatrics (ABP) Foundation, a nonprofit, supporting organization to the ABP. M.L.M. and G.L.F. were contracted to lead in developing the study design; analyzing the data; and drafting, editing, and submitting the manuscript. L.K.L. is an employee of the American Board of Pediatrics (ABP) and received salary compensation for their role in this research, including the collection, analysis, and interpretation of data; preparation of the manuscript; and the decision to submit the article for publication. The content is solely the responsibility of the authors and does not necessarily represent the official views of the ABP or the ABP Foundation.

AUTHOR CONTRIBUTIONS

Substantial contributions to concept and design, acquisition of data, or analysis and interpretation of data: M.L.M., K.D.V., L.K.L., G.L.F. Drafting the article or revising it for critically important intellectual content: M.L.M., K.D.V., L.K.L., G.L.F. Final approval of the version to be published: M.L.M., K.D.V., L.K.L., G.L.F.

ADDITIONAL INFORMATION

Competing interests: The authors declare no competing interests.

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

REFERENCES

1. Rivkees, S. A. & Genel, M. American pediatric academia: the looming question. *J. Pediatrics* **151**, 223–224 (2007).
2. McKinney, R. E. Jr. The daunting career of the physician-investigator. *Academic Med.: J. Assoc. Am. Med. Coll.* **92**, 1368–1370 (2017).
3. Furuya, H., Brenner, D. & Rosser, C. J. On the brink of extinction: the future of translational physician-scientists in the United States. *J. Transl. Med.* **15**, 88 (2017).
4. Donowitz, M., Germino, G., Cominelli, F. & Anderson, J. M. The attrition of young physician-scientists: problems and potential solutions. *Gastroenterology* **132**, 477–480 (2007).
5. Daye, D., Patel, C. B., Ahn, J. & Nguyen, F. T. Challenges and opportunities for reinvigorating the physician-scientist pipeline. *J. Clin. Investig.* **125**, 883–887 (2015).
6. Daniels, R. J. A generation at risk: young investigators and the future of the biomedical workforce. *Proc. Natl. Acad. Sci. USA* **112**, 313–318 (2015).
7. Cornfield, D. N. et al. Patching the pipeline: creation and retention of the next generation of physician-scientists for child health research. *J. Pediatrics* **165**, 882–4.e1 (2014).
8. Cornfield, D. N., Lane, R. & Abman, S. H. Creation and retention of the next generation of physician-scientists for child health research. *JAMA* **309**, 1781–1782 (2013).
9. Abkowitz, J. L. & Hromas, R. Confronting the research funding crisis: medical societies' role in filling the gap. *Academic Med.: J. Assoc. Am. Med. Coll.* **93**, 961–962 (2018).
10. Hromas, R., Abkowitz, J. L. & Keating, A. Facing the Nih funding crisis: how professional societies can help. *JAMA* **308**, 2343–2344 (2012).
11. Salata, R. A. et al. U.S. physician-scientist workforce in the 21st century: recommendations to attract and sustain the pipeline. *Acad. Med.: J. Assoc. Am. Med. Coll.* 565–573 (2017).
12. National Institutes of Health Physician-Scientist Workforce Working Group Report. https://report.nih.gov/workforce/psw/index.aspx (2014).
13. Daniels, R. & Dzau, V. Supporting the next generation of biomedical researchers. *JAMA* **320**, 29–30 (2018).
14. Hirschtritt, M. E., Heaton, P. M. & Insel, T. R. Preparing physician-scientists for an evolving research ecosystem. *JAMA* **320**, 31–32 (2018).
15. Nichols, D. G. & Lister, G. The physician-scientist workforce and board certification. *JAMA Pediatrics* **169**, 417–418 (2015).
16. Burns, A. M. et al. Strengthening the pipeline for clinician-scientists: the pediatrician-scientist training and development program at Texas Children's Hospital. *J. Pediatrics* **172**, 5–6 e5 (2016).
17. Burns, A. M. et al. Implementation of a novel curriculum and fostering professional identity formation of pediatrician-scientists. *J. Pediatrics* **205**, 5–7 e1 (2019).
18. Hurst, J. H. et al. Cultivating research skills during clinical training to promote pediatric-scientist development. *Pediatrics* **144**, e20190745 (2019).
19. Rivkees, S. A. The missing link of Nih funding in pediatric research training program restructuring. *Pediatrics* **134**, e1521–e1522 (2014).
20. Twombly, D. A. et al. Association of National Institute of Child Health and Human Development Career Development Awards with subsequent research project grant funding. *JAMA Pediatrics* **172**, 226–231 (2018).
21. Pediatric Scientist Development Program (Psdp) Website. Duke University Medical Center. https://amspdc-psdp.org/ (2019).
22. Dermody, T. S., Hirsch, R., Hostetter, M. K., Orange, J. S. & St Geme, J. W. 3rd Expanding the pipeline for pediatric physician-scientists. *J. Pediatrics* **207**, 3–7 e1 (2019).
23. Good, M., McElroy, S. J., Berger, J. N. & Wynn, J. L. Name and characteristics of National Institutes of Health R01-Funded Pediatric Physician-Scientists: hope and challenges for the vanishing pediatric physician-scientists. *JAMA Pediatrics* **172**, 297–299 (2018).
24. Dickler, H. B., Fang, D., Heinig, S. J., Johnson, E. & Korn, D. New physician-investigators receiving National Institutes of Health research project grants: a historical perspective on the "endangered species". *JAMA* **297**, 2496–2501 (2007).
25. Gitterman, D. P., Langford, W. S. & Hay, W. W. The uncertain fate of the National Institutes of Health (Nih) pediatric research portfolio. *Pediatr. Res.* **84**, 328–332 (2018).
26. Gitterman, D. P., Langford, W. S. & Hay, W. W. Jr. The fragile state of the National Institutes of Health Pediatric Research Portfolio, 1992−2015: doing more with less? *JAMA Pediatrics* **172**, 287–293 (2018).
27. Jeffe, D. B. & Andriole, D. A. Prevalence and predictors of US Medical Graduates' Federal F32, Mentored-K, and R01 Awards: a national cohort study. *J. Investigative Med.: Off. Publ. Am. Federation Clin. Res.* **66**, 340–350 (2018).
28. Schwartz, A. L. Physician-scientist career awards and a dilemma: National Institute of Child Health and Human Development K Awards—individual, institutional, or national? *JAMA Pediatrics* **172**, 218–219 (2018).
29. American Board of Pediatrics. *Pediatric Physicians Workforce Data Book, 2017−2018* (American Board of Pediatrics, Chapel Hill, NC, 2018).
30. American Board of Pediatrics Subspeciality Fellowship Tracking Data. https://www.abp.org/content/subspecialty-fellowship-tracking-data#overlay-context=content/general-information-all-certified-diplomates (2018).