Postdoctoral National Institutes of Health F32 Grants

Broken Pipeline in the Development of Surgeon-Scientists

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Objective: We examined trainees in surgery and internal medicine who received National Institutes of Health (NIH) F32 postdoctoral awards to determine their success rates in obtaining future NIH funding.

Background: Trainees participate in dedicated research years during residency (surgery) and fellowship (internal medicine). They can obtain an NIH F32 grant to fund their research time and have structured mentorship.

Methods: We collected NIH F32 grants (1992–2021) for Surgery Departments and Internal Medicine Departments from NIH RePORTER, an online database of NIH grants. Nonsurgeons and noninternal medicine physicians were excluded. We collected demographic information on each recipient, including gender, current specialty, leadership positions, graduate degrees, and any future NIH grants they received. A Mann-Whitney U test was used for continuous variables, and a χ^2 test was utilized to analyze categorical variables. An alpha value of 0.05 was used to determine significance.

Results: We identified 269 surgeons and 735 internal medicine trainees who received F32 grants. A total of 48 surgeons (17.8%) and 339 internal medicine trainees (50.2%) received future NIH funding ($P < 0.0001$). Similarly, 24 surgeons (8.9%) and 145 internal medicine trainees (19.7%) received an R01 in the future ($P < 0.0001$). Surgeons who received F32 grants were more likely to be department chair or division chiefs ($P = 0.0055$ and $P < 0.0001$).

Conclusions: Surgery trainees who obtain NIH F32 grants during dedicated research years are less likely to receive any form of NIH funding in the future compared with their internal medicine colleagues who received F32 grants.

Keywords: education, NIH grants, F32, research

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Physician-scientists play a very important role in the advancement of biomedical science.[1] Performing research is an important endeavor for trainees during residency. Dedicated research time during residency allows trainees to be free of clinical duties and gives residents an opportunity to establish a research foundation.[2] Research during residency also offers residents an opportunity to bolster their CV for fellowship matches and job opportunities.[3,4] However, increased difficulties in obtaining funding and increasing clinical pressures have made pursuing a career as a physician-scientist arduous.[5–7]

Funding for dedicated research time is highly sought after as residents are usually not earning a salary by performing clinical duties.[8] Numerous modalities currently exist for funding postdoctoral research, including National Institutes of Health (NIH) T32 training grants, NIH F32 National Research Service Award Individual Postdoctoral Fellowship, societal grants, foundation grants, non-NIH governmental fellowships (NSF etc.), funding from a mentors' R01, institutional awards/grants, and departmental funds. NIH F32 grants are awarded to the trainee as the principal investigator, with their mentor serving as the sponsor.[9] The F32 grant includes stipends, tuition and fees, and institutional allowance. F32s can last up to 3 years or the duration of dedicated research time, whichever is shorter.[10] Further, these awards require a structured mentorship and an education plan to provide trainees with biomedical education for future research endeavors, ideally future grant funding.

Dedicated research time (1–3 y) for surgery residents usually occurs between clinical PGY2 and PGY3 years or between PGY3 and PGY4 years.[11] Dedicated research time for internal medicine trainees usually occurs during their fellowship years or between their residency and fellowship. The American Board of Internal Medicine has established a research track for interested trainees.[12] Some institutions have established Physician Scientist Training Programs to aid in this American Board of Internal Medicine research training paradigm. Physician Scientist Training Programs allow for shorter clinical training and built-in dedicated research time during which trainees are eligible for F32s or other postdoctoral research awards. To this end, we evaluated the outcomes of surgeons and internal medicine trainees who received NIH F32 grants.

METHODS

Collection of Grant Data

The National Institutes of Health (NIH) Research Portfolio Online Reporting Tools Expenditures and Results (RePORTER) database was queried for F32 grants (NIH Ruth L. Kirschstein National Research Service Award Individual Postdoctoral Fellowship). Grants awarded to physicians (MD, DO, MBBS, or equivalent) in Internal Medicine and Surgery Departments were collected. Grants awarded to individuals who are PhD-only scientists or in nonsurgical specialties from Surgery Departments after their clinical training were excluded.

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Physicians going into nonmedicine specialties were removed from the Medicine F32 group. When analyzing future grant funding, surgery residents who are still in training were excluded from that analysis (n = 30). F32 grants from 1992 to 2021 were collected. F32 principal investigators were queried in NIH RePORTER to collect any subsequent grants (NIH and AHRQ) after their initial F32 grant. A Python tool built using the BeautifulSoup and Selenium packages was used to query the NIH

RePORTER website. For each grant, the Python tool collected the title, grant number, NIH institute, principal investigator's name/home institution, grant start/end dates, total funding in USD, and PMID of each publication. The NIH iCite application programming interface was used to collect the total number of citations for each publication.[13]

Collection of Demographic Information

The principal investigators of each F32 grant were queried online for their demographic information. Institutional faculty web pages, Doximity, and LinkedIn were utilized to collect information regarding investigators.[14,15] The following information for each investigator was collected: current institution, specialty, gender, additional degrees, professorship level (if applicable), and any leadership positions.

Calculation of Grant Impact Metric

The PubMed Unique Identifier (PMID) of each manuscript from a grant was collected. The PMID was then queried in the National Institute of Health's iCite database.[13] Citations for each manuscript were collected. A previously published Grant Impact Metric was calculated for each grant as follows: Sum of citations of all manuscripts resulting from that grant/funding for the grant (per $100,000).[16–19] For example, a grant with 5 publications totaling 100 citations with $200,000 in funding would have a grant impact metric of 50 (100/[200,000/100,000]).

Statistical Analysis

GraphPad Prism version 9.2.0 for MacOS (GraphPad Software San Diego, CA) was utilized for all statistical analyses. A Mann-Whitney *U* test was used for continuous variables, and a χ^2 test was utilized to analyze categorical variables. An alpha value of 0.05 was used to determine significance.

RESULTS

F32 Awardee Characteristics

A total of 1494 postdoctoral National Institutes of Health Ruth L. Kirschstein National Research Service Awards (NRSA, F32) grants were awarded to Surgery Departments and Internal Medicine Departments between 1992 and 2021 (Fig. 1). Of the 1494 grants, 347 were awarded to Surgery Departments, and 1147 were awarded to Internal Medicine Departments. After the exclusion of nonclinician scientists (no MD or equivalent), our cohorts were 269 surgeons and 735 medicine physicians. Surgeons published 1120 manuscripts, which generated over 29,000 citations with ~$20 million in funding. Internists published 1610 manuscripts which generated over 75,000 citations with ~$61 million in funding. The majority of F32 recipients are male, with a significantly higher proportion of males in surgery (77.3% vs. 62.4%; $P < 0.0001$) (Table 1). Internal medicine F32 trainees hold significantly more leadership positions (28.6% vs. 20.8%; $P = 0.0137$); however, surgeons hold more department chair (2.6% vs. 0.5%; $P = 0.0055$) and division chief positions (7.8% vs. 2.2%; $P < 0.0001$).

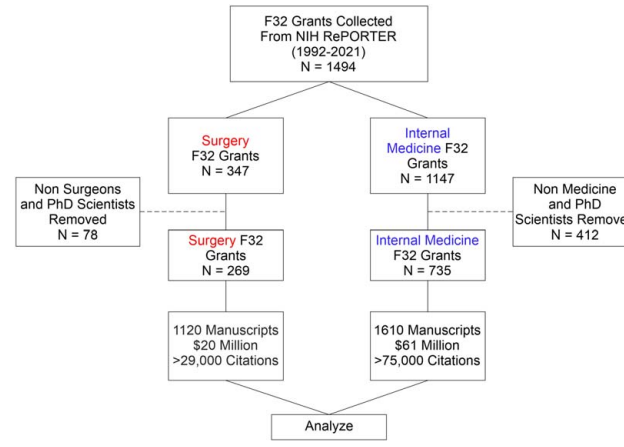

FIGURE 1. CONSORT Diagram of Study: 1494 F32 grants were identified, with 347 for Surgery Departments and 1147 for Internal Medicine Departments. After the exclusion of nonphysicians and physicians from other specialties, 269 surgery F32s and 735 internal medicine F32s remained.

We evaluated the number of F32 trainees who have an additional graduate degree to their MD or equivalent degree. Specifically, we find that significantly more internal medicine trainees have a graduate degree compared with surgery trainees (34.7% vs. 17.5%; $P < 0.0001$). Internal medicine trainees have significantly more Masters in Science degrees (10.6% vs. 3.0%; $P = 0.0001$). Although internal medicine trainees have a higher percentage of PhD recipients, this was not statistically significant (13.2% vs. 9.3%; $P = 0.0936$).

Specialties of F32 Recipients

Of the 269 surgery F32 recipients, cardiothoracic surgery (34.6%), vascular surgery (12.3%), and pediatric surgery (7.4%) had the highest number of trainees (Supplemental Table 1, Supplemental Digital Content 1, http://links.lww.com/SLA/E700). The specialties with the fewest F32 recipients were breast, burn, and hand surgery (all 1 trainee each, 0.4%). Of the 735 internal medicine F32 recipients, pulmonology and critical

TABLE 1. Characteristics of F32 Recipients

	Surgery n = 269 (%)	Internal medicine n = 735 (%)	*P*
Gender			
Male	208 (77.3)	459 (62.4)	< 0.0001
Female	61 (22.7)	276 (37.6)	< 0.0001
Any leadership position	56 (20.8)	210 (28.6)	0.0137
Department Chair	7 (2.6)	4 (0.5)	0.0055
Division Chief	21 (7.8)	16 (2.2)	< 0.0001
Other	28 (10.4)	190 (25.9)	< 0.0001
Currently in training	30 (11.2)	19 (2.6)	< 0.0001
Any graduate degree	47 (17.5)	255 (34.7)	< 0.0001
MBA	6 (2.2)	11 (1.5)	0.4247
MPH	8 (3.0)	38 (5.2)	0.1405
MS	8 (3.0)	78 (10.6)	0.0001
PhD	25 (9.3)	97 (13.2)	0.0936
Other	1 (0.4)	31 (4.2)	0.0021

care (282; 38.4%), cardiology (137; 18.6%), and nephrology (116; 15.8%) had the highest number of grant awardees (Supplemental Table 2, Supplemental Digital Content 1, http://links.lww.com/SLA/E700). The fewest number of internal medicine recipients were in allergy/immunology, genetics, and hepatology (all 1 trainee each, 0.1%).

National Institutes of Health Institutional Analysis

A total of 1004 F32 grants were analyzed in our study after meeting the exclusion criteria. Of these 1004 grants, 542 (54%) were awarded by the National Heart, Lung, and Blood Institute (Table 2). Approximately the same percentage were funded for both Surgery (144; 55.5%) and Internal Medicine (398; 54.1%) ($P = 0.8619$). Internal Medicine trainees received significantly more F32 grants from the National Institute of Diabetes and Digestive and Kidney Diseases (208 [28.3%] vs. 36 [13.4%]; $P < 0.0001$). However, Surgery trainees were awarded significantly more grants from the National Cancer Institute (26 [9.7%] vs. 19 [2.6%]; $P < 0.0001$) and the National Institute of General Medical Sciences (26 [9.7%] vs. 8 [1.1%]; $P < 0.0001$). Both departments were awarded a similar number of grants from the National Institute of Allergy and Infectious Diseases (10 [3.7%] vs. 34 [4.6%]; $P = 0.5335$). The remaining institutes all awarded fewer than 20 grants to either trainee type.

Surgery Trainees Who Converted F32 to Future NIH Funding

There were no differences in the number of male surgeons who converted their F32 into any form of future NIH funding compared with female surgeons ($P = 0.9222$) (Table 3). A higher proportion of F32 converters were vascular surgeons (11 [22.9%] vs. 21 [11%]; $P = 0.0301$). However, no other surgical specialty obtained NIH funding at a higher proportional rate. Surgeons who converted their F32 were likely to hold a leadership position at some point in their career (30 [62.5%] vs. 48 [25.1%]; $P < 0.0001$). They were more likely to be department chairs (4 [8.3%] vs. 3 [1.6%]; $P = 0.0130$), division chiefs (10 [20.8%] vs. 13 [6.8%]; $P = 0.0032$), or hold other leadership positions (16 [33.3] vs. 32 [16.8]; $P = 0.0104$). Successful F32 converters published more median manuscripts (3 [1–5.8] vs. 2 [0–4]; $P = 0.0369$), which received more citations (69.5 [11.3–223.5] vs. 23 [0–111]; $P = 0.0175$) and had a higher grant impact metric (103.1 [10.0–414.7] vs. 42.6 [0–169.9]; $P = 0.0189$).

Internal Medicine Trainees Who Converted F32 to Future NIH Funding

We found no differences in the gender of internal medicine trainees who were able to obtain NIH funding after their F32 grants ($P = 0.2901$) (Table 4). Cardiology was the only specialty that had difficulty in converting F32 funding into future NIH funding (53 [15.6%] vs. 85 [21.5%]; $P = 0.0436$). Trainees who obtained NIH funding after their F32 had significantly more graduate degrees than the trainees who did not convert their F32 grant (148 [43.7%] vs. 108 [27.3%]; $P < 0.0001$). This trend is driven by trainees who have Masters in Science degrees (49 [14.5%] vs. 29 [7.3%]; $P = 0.0018$) and trainees who have PhDs (58 [17.1%] vs. 39 [9.8]; $P = 0.0024$). A slightly higher grant funding amount was found for trainees who converted to future NIH funding (73,298 vs. 69,100; $P = 0.0131$). Importantly, F32 converters published more manuscripts (2 [0–4] vs. 1 [0–2]; $P < 0.0001$) that received more citations (72 [12–187] vs. 8 [0–50]; $P < 0.0001$), and had a higher grant impact metric for their F32 (76.4 [11.1–218.2] vs. 6.7 [0–63.1]; $P < 0.0001$).

F32 Trainee Subsequent NIH Grants

Surgeons with F32 grants (n = 239) obtained a total of 120 subsequent NIH grants totaling $176 million in funding, resulting in 2616 publications and generating over 81,000 citations (Table 5). The most common grant obtained after an F32 was an R01 (n = 50, $131 million, 1485 publications, 41,684 citations). Of the 239 F32 grantees, 18 were able to obtain a K award in their junior faculty years (18/239; 7.5%) (Fig. 2). Of the 18 K-awardees, 7 surgeons were able to obtain an R01 (7/18; 38.9%). However, 17 surgeons were able to obtain an R01 without first receiving a K-award. A total of 24 surgeons were able to obtain an R01 after receiving an F32 award (24/239; 10.0%), with 7 following the F32 to K-award to R01 paradigm (7/239; 2.9%).

Of 735 Internal Medicine F32 recipients, 274 were able to obtain a K award (274/735; 37.3%), and 112 were able to convert their K award into an R01 (112/274; 40.8%) (Fig. 2B). A total of 145 investigators were able to obtain an R01 after receiving their F32 (145/735; 19.7%) with 112 following the F32 to K-award to R01 paradigm (112/735; 15.2%). Comparatively, internal

TABLE 2. Institutes Funding F32 Grants for Surgery and Internal Medicine

Institute	Surgery n = 269 (%)	Internal medicine n = 735 (%)	*P*
National Heart, Lung, and Blood Institute	144 (55.5)	398 (54.1)	0.8619
National Institute of Diabetes and Digestive and Kidney Diseases	36 (13.4)	208 (28.3)	< 0.0001
National Cancer Institute	26 (9.7)	19 (2.6)	< 0.0001
National Institute of General Medical Sciences	26 (9.7)	8 (1.1)	< 0.0001
National Institute of Allergy and Infectious Diseases	10 (3.7)	34 (4.6)	0.5335
National Institute of Arthritis and Musculoskeletal and Skin Diseases	8 (3.0)	11 (1.5)	0.1266
National Institutes of Neurological Disorders and Stroke	6 (2.2)	0 (0.0)	< 0.0001
Agency for Healthcare Research and Quality	3 (1.1)	16 (2.2)	0.2742
National Institute of Dental and Craniofacial Research	3 (1.1)	1 (0.1)	0.0292
National Institute of Aging	3 (1.1)	8 (1.1)	0.9696
National Institute on Deafness and Other Communication Disorders	2 (0.74)	0 (0.0)	0.0193
Eunice Kennedy Shriver National Institute of Child Health and Human Development	1 (0.4)	12 (1.6)	0.1175
National Institute of Biomedical Imaging and Bioengineering	1 (0.4)	0 (0.0)	0.0982
National Institute of Environmental Health Sciences	0 (0)	11 (1.5)	0.0439
National Institute on Alcohol Abuse and Alcoholism	0 (0)	6 (0.8)	0.1372
National Institute on Drug Abuse	0 (0)	3 (0.4)	0.2940

TABLE 3. Surgery F32 Grant Analysis

Characteristic	Future NIH funding n = 48 (%)	No Future NIH funding n = 191* (%)	P
Gender			
Male	39 (81.2)	154 (80.6)	0.9222
Female	9 (18.8)	37 (19.4)	0.9222
Specialty			
Cardiothoracic	15 (31.3)	78 (40.8)	0.2232
Vascular	11 (22.9)	21 (11.0)	0.0301
Pediatric	6 (12.5)	14 (7.3)	0.2475
Plastic	3 (6.3)	13 (6.8)	0.8904
Colorectal	2 (4.2)	6 (3.1)	0.7240
Other	11 (22.9)	59 (30.9)	0.2779
Graduate degree	9 (18.8)	33 (17.3)	0.8106
MBA	0 (0)	6 (3.1)	0.2136
MPH	3 (6.3)	4 (2.1)	0.1269
MS	2 (4.2)	5 (2.6)	0.5694
PhD	3 (6.3)	17 (8.9)	0.5533
Other	1 (2.1)	1 (0.5)	0.2889
Leadership position	30 (62.5)	48 (25.1)	< 0.0001
Department Chair	4 (8.3)	3 (1.6)	0.0130
Division Chief	10 (20.8)	13 (6.8)	0.0032
Other	16 (33.3)	32 (16.8)	0.0104
F32 Funding (Median)†	66978 [45788–98766]	61110 [47413–93600]	0.3170
Publications†	3 [1–5.8]	2 [0–4]	0.0369
Citations†	69.5 [11.3–223.5]	28 [0–111]	0.0175
Grant Impact Metric†	103.1 [10.0–414.7]	42.6 [0–169.9]	0.0189

*Current residents not included.
†Median [Interquartile Range].

TABLE 4. Internal Medicine F32 Grant Analysis

Characteristic	Future NIH funding n = 339 (%)	No Future NIH funding n = 396 (%)	P
Gender			
Male	219 (64.6)	240 (60.6)	0.2901
Female	120 (35.4)	156 (39.4)	0.2901
Specialty			
Pulm/Crit Care	138 (40.7)	144 (36.4)	0.2273
Nephrology	55 (16.2)	61 (15.4)	0.7611
Cardiology	53 (15.6)	85 (21.5)	0.0436
Endocrinology	28 (8.3)	42 (10.6)	0.2800
Gastroenterology	19 (5.6)	34 (8.6)	0.1193
Other	46 (13.6)	30 (7.6)	0.0078
Graduate degree	148 (43.7)	108 (27.3)	< 0.0001
MBA	5 (1.5)	6 (1.5)	0.9743
MPH	20 (5.9)	19 (4.8)	0.5065
MS	49 (14.5)	29 (7.3)	0.0018
PhD	58 (17.1)	39 (9.8)	0.0024
Other	16 (4.7)	15 (3.8)	0.5309
Leadership position	148 (43.7)	103 (26.0)	< 0.0001
Department Chair	3 (0.9)	3 (0.8)	0.8483
Division Chief	21 (6.2)	9 (2.3)	0.0074
Other	124 (36.6)	91 (23.0)	< 0.0001
F32 Funding (Median)†	73298 [59745–113388]	69100 [53023–108627]	0.0131
Publications†	2 [1–4]	1 [0–2]	< 0.0001
Citations†	72 [12–187]	8 [0–50]	< 0.0001
Grant Impact Metric†	76.4 [11.1–218.2]	6.7 [0–63.1]	< 0.0001

†Median [Interquartile Range].

medicine F32 awardees are more successful at converting their F32 into a K-award (37.3% vs. 7.5%; $P < 0.0001$) and converting their F32 into an R01 (10.0% vs. 19.7%; $P < 0.0001$). Further, a significantly higher proportion of Internal Medicine F32 awardees were able to transition from an F32 to a K-award to an R01 (112/735 [15.2%] vs. 7/239 [2.9%]; $P < 0.0001$).

DISCUSSION

National Institutes of Health F32 Postdoctoral awards are utilized by trainees in residency and fellowship as funding for their salary during dedicated research time. These awards are highly coveted and require the trainee to submit a full NIH grant. F32 grants also provide trainees with a research foundation for future scientific pursuits. Therefore, evaluating the trainees who receive F32s and following their NIH funding trajectory allows for determining the utilization of these grants. We find that surgery residents are equally prolific in obtaining F32 awards compared with their internal medicine colleagues. Surgery residents publish equally well compared with their medicine colleagues during dedicated research years (grant impact metric 103.1 vs. 76.4; $P = 0.2881$) (Tables 3 and 4). However, surgeons are unable to convert their success during their dedicated research years into a K-award or R01 funding at rates comparable to their medicine colleagues.

In 2020–2021, there were 9854 general surgery trainees and 29,564 internal medicine trainees.[20] Accounting for the size of each specialty, there were no differences in the rates at which surgeons or internal medicine physicians obtained F32 grants (269/9,854 [2.7%] vs. 735/29,564 [2.5%]; $P = 0.1835$). However, internal medicine trainees are 5 times more likely to obtain a K-award (37.3% vs. 7.5%; $P < 0.0001$) and almost 6 times more likely to obtain R01 funding (112/735 [15.2%] vs. 7/239 [2.9%]; $P < 0.0001$). The amount of effort required to obtain an F32 grant and perform the proposed research indicates a certain level of interest in pursuing research. This shocking drop-off in future NIH funding illuminates a major problem in our specialty. Surgeons are successful at obtaining funding for dedicated research time but are unable to obtain this funding later in their careers. A few reasons for this may be that surgery as a specialty has a unique set of limitations: continuous need to maintain technical skill, demand from hospital leadership to generate revenue, and time demands of clinical work.[6,21,22] An active effort by health system leadership to evaluate surgeon-scientists by a different set of metrics compared with strictly clinical surgeons may abrogate some of these concerns and encourage surgeons to pursue research.[23]

Dedicated research time for surgery residency is usually between PGY2 and PGY3 or PGY3 and PGY4. For internal medicine trainees, their dedicated research time occurs between residency and fellowship or as a part of their fellowship. For surgery, residents who pursue a fellowship (1–3 years after residency), a 2 to 6-year gap may be present between the end of their dedicated research time and the start of their faculty position.

TABLE 5. Surgery Subsequent Grant Characteristics

Grant Type	N	Funding	Publications	Citations
All Grants	120	176,784,394	2616	81096
R01	50	131,940,819	1485	41684
K08/K23	18	11,820,344	275	7364
R21	7	3,009,804	51	4280
I01	7	Unavailable	32	213
Other	38	30,013,427	773	27015

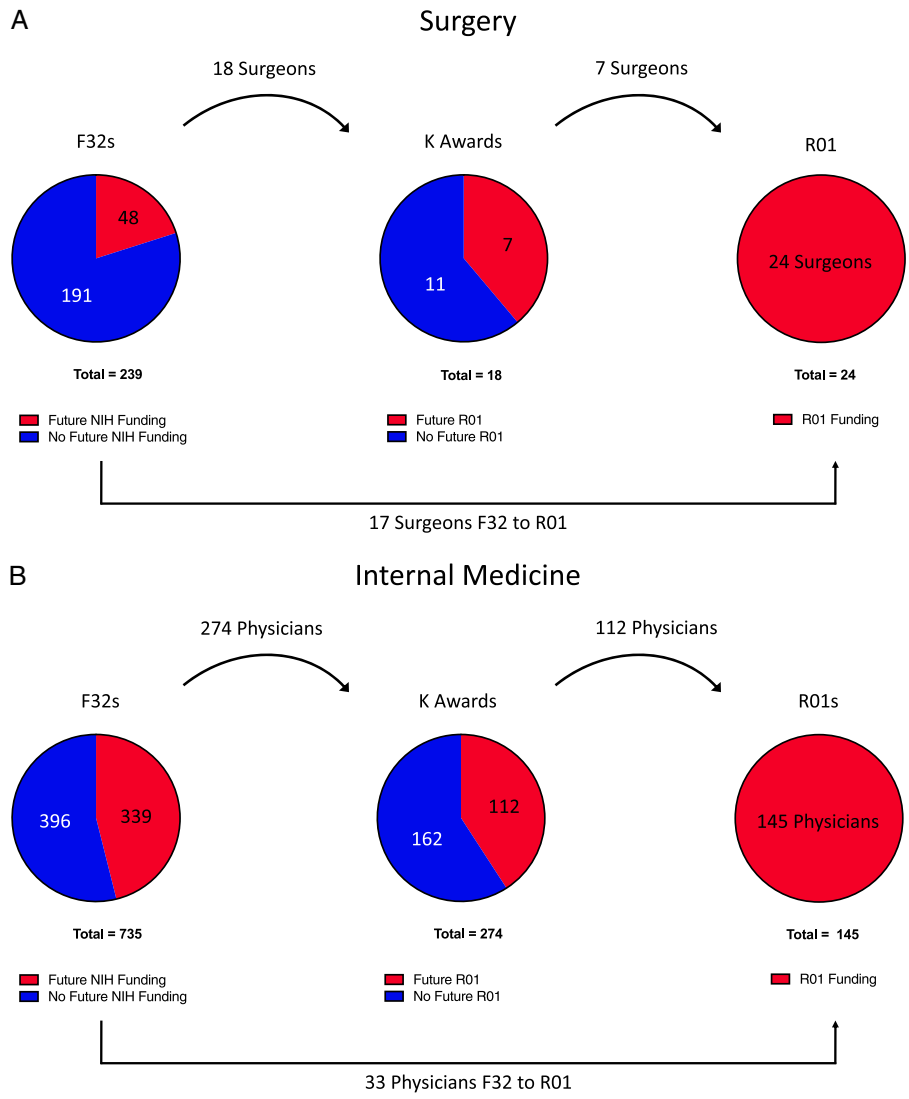

FIGURE 2. **(A)** Surgery F32 Recipients Progression: Flow diagram of surgery F32 recipients from F32 grants to K-awards to R01 funding. Left: Of the 239 F32 recipients, 48 obtained any form of future NIH funding and 191 did not. Of the 48 surgeons, 18 obtained a K-award, 17 went directly from an F32 to an R01, and the remaining 13 obtained other NIH grants. Center: A total of 18 surgery trainees received K-awards. Seven K-awardees received an R01 in the future. Right: A total of 24 surgeons obtained R01s. **(B)** Internal Medicine F32 Recipients Progression: Flow diagram of internal medicine F32 recipients from F32 grants to K-awards to R01 funding. Left: Of the 735 F32 recipients, 339 obtained any form of future NIH funding and 396 did not. Of the 339 internal medicine trainees, 274 obtained a K-award, 33 went directly from an F32 to an R01, and the remaining 32 obtained other NIH grants. Center: A total of 274 surgery trainees received K-awards. One hundred and twelve K-awardees received an R01 in the future. Right: A total of 145 physicians obtained R01s.

Internal medicine trainees have a 0 to 3-year gap after their dedicated research years. The relatively short hiatus in research for internal medicine trainees allows them to maintain research momentum, and any data generated during their dedicated research years can be used for K-awards or R01 grants. Further, internal medicine trainees are eligible for K99/R00 awards through the NIH as they can directly transition from their postdoctoral research years (K99) to their junior faculty years (R00).[24] Due to PGY4, PGY5, and any clinical fellowship years required for surgery residents, the K99/R00 pathway is not a feasible option as the K99 and R00 periods have to be sequential. Further, with the pace of biomedical research and lost momentum, surgery residents will have to spend their junior faculty years building up their research enterprise before applying for grants.

One potential funding mechanism that may help surgery trainees succeed in obtaining future NIH funding is the R38 Stimulating Access to Research in Residency grant. These grants are awarded at the institutional/departmental level.[25] Similar to T32 grants, these grants fund trainees during their research years; however, R38 trainees are eligible for K38 grants (only available to R38 trainees).[26] K38 grants fund trainees as they complete their residency training and make funds available for the continuation of their research from dedicated research years. These funds can be used for supplies, technical support, or statistician support in addition to salary support for the resident. Trainees are then eligible for traditional K08/K23 grant mechanisms in their junior faculty years. Currently, there are 35 active R38 grants in the United States, and institutions committed to training surgeon-scientists should consider applying for these grants. Further, societal grants and institutional/departmental funds can help bridge surgery residents from their research years to junior faculty years to continue their research and not lose momentum.

Surgeons and internal medicine specialists aiming to receive F32 funding should apply to the institutes where their work is most applicable. However, NHLBI, NIDDK, NCI, NIGMS, and NIAID have all funded the most F32s for surgeons and internal medicine trainees. The F32 application success rates for these institutes in FY2023 were: NHLBI (36%), NIDDK (24.1%), NCI (15.3%), NIGMS (30.9%), and NIAID (8.7%).[27]

Due to a high number of funded grants, trainees may want to gear their applications towards NHLBI, NIGMS, or NIDDK to improve their chances of receiving funding.

Cardiothoracic and vascular surgeons receive the greatest number of F32 awards (126/269; 46.8%). It is possible the that the competitive nature of these specialties and the availability of surgeon-scientist labs in these fields promote surgery residents applying for F32s and then going into those fields.[7]

One major limitation of our work is that we have focused on F32 grants and subsequent grants from the National Institutes of Health and have not considered other grant modalities. The NIH is the largest funding body of biomedical research in the world, and we are able to extrapolate trainee trends based on these data.[28] Our analysis of trainee demographics is limited by the accuracy of the information on departmental faculty web pages, Doximity pages, and Linkedin pages. The majority of these pages are populated by the listed physician. Another limitation of our work is that few surgeons received their F32 from a medicine department (< 2% of medicine F32s) and were excluded from that group. One limitation regarding time bias is that surgeons do have a longer training route, and we have performed an unbiased examination of conversation rates. Finally, we do not have information on the number of surgeons or internal medicine physicians who applied for funding and did not receive it, but only those who did receive funding.

In conclusion, surgery residents obtain F32 awards at similar rates compared with their internal medicine colleagues. However, they have not been able to convert these awards into K-awards or R01 funding. Surgery residents are faced with challenges, including long periods of clinical training without the opportunity for research continuity. In order for surgeon-scientists to thrive, alternate grant funding mechanisms may be needed, and institutions need to establish support during post-research years for those residents who wish to pursue research. With increasing difficulty in obtaining funding and establishing a research program, the surgeon-scientist as we know it may become extinct without action.

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DISCUSSANT

Dr. Martha Zeiger (Bethesda, MD)

Dr. Narahari, I applaud you and your coauthors for examining this very important and timely question. The leaders in the American College of Surgeons and the American Surgical Association, Drs. Ellison, Farmer, and Stain, are examining this very issue.

I have a couple questions and comments. When you evaluated trainees, you state you also evaluated trainees who have graduate degrees. I think you mean trainees with additional degrees such as PhD in addition to MD, DO, MBBS. Also, please confirm that DOs and MBBSs were included in your analysis. This is not stated.

If a surgical resident had an F32 in a medicine department, it appears as though you excluded them from your analysis. I think it's extremely important for us to look at surgeons' success rates, and not department's success rate. Many prominent surgeon-scientists did their F32 in a medicine department. If a medicine resident has an F32 in a surgery department I think they should be similarly evaluated.

You correctly state that F32 training for nonsurgeons is usually later in residency. Therefore, surgeons are applying for grants many, many years later than our medicine colleagues. However, aside from the one table in which you excluded surgical residents who obviously couldn't be NIH-funded, you did not account for this time difference. For example, even 5 years out from an F32 a surgeon is still in fellowship. When we examined NIH Portfolio, the average time for a surgeon to receive a K award after an F32 versus a medicine resident, was 10 years compared with 3 years. This timeframe needs to be accounted for in your analysis. When we take that into account and when we look at surgeon success rate, the success rate is 22%, or much higher. This is only for K grants, so the success rates that include other grants would be even higher.

Although you say most of the NIH grants are from NHLBI, NIGMS, NIDDK and therefore one should apply to these institutes, it's important to know the denominator, namely, number of applicants. We don't want to encourage people to specifically apply to these institutes without knowing the success rates.

And I leave you with "the future is bright". If you look at all surgeon-scientists, (we published this recently in JACS) and not just departments, not just Blue Ridge, NIH-funded surgeon-scientists are increasing, whereas our non-surgeon colleagues are decreasing in numbers. Those specialties that are most purposeful in the integration of surgical and research training are neurosurgeons, otolaryngologists, urologists, are also the most successful surgeons in terms of obtaining NIH funding. Thank you for allowing me to review your paper, and congratulations.

Response from Adishesh Narahari

Thank you, Dr Zeiger, for those comments and for talking to us about how good the future is going to be.

For your first question, looking at F32 grants to surgeons in surgery departments versus internal medicine departments, so we actually didn't find that many surgeons when we looked at internal medicine departments, and I think there were maybe less than 10 when we looked, but we felt that looking at our numbers, 270 versus 735, that it would be okay to proceed with this. We actually did collect data on all other surgeons as well, such as neurosurgeons and OB/GYNs, but we chose not to look at that data for this particular paper.

And for your second question, we totally agree. One of the reasons why we did this paper was to address the time lag between dedicated research years and also the first grant application for surgery trainees, and in internal medicine, the research generally occurs during their fellowship, and then they go out into faculty, and they can apply for a K award as you said within three years, and they get it, and for surgeons, it's almost 10 years, and the research changes, and you get left behind if you have a decade between your research and your K award, so we think that that's one of the reasons we wanted to highlight that there needs to be a change in maybe when the research years occur versus general surgery residency or maybe attached to the fellowship instead.

And the third was looking at the denominator of the grant applications at the institutes. We totally agree. Unfortunately, we didn't have access to the number of applications at these institutes. We only had access to the funded applications, and certainly these institutes are likely having large numbers of applications and they tend to fund a percentage of those. Some of the other institutes don't necessarily want to fund F32 grants because that's not one of their priorities, so thank you for highlighting that important fact.

And finally, you're absolutely right. We published a paper I think in 2017 in JACS looking at surgeon-scientists and how well they do once they're able to obtain funding or at the rates that they obtain funding, so they're very competitive when they apply for them, and the important thing is to get them there to apply for these grants, and once they get them, they're actually publishing very impactful manuscripts, and we addressed this looking at our grant impact metric, so we advocate for surgeons applying for these grants. It's just giving them the opportunity to do so, so thank you very much for your discussant questions.

Dr Keith Lillemoe (Boston, MA)

Congratulations, Adishesh. For those who don't know, Adishesh is a graduating medical student at the University of Virginia, who was in the match this year and matched in cardiac surgery at UVA. He is a very sharp young man who has thought deeply about these issues.

So, most of us are a product of a system where we trained. Most of us did a couple clinical years, a couple research years, and then completed our training including fellowships. So, it is often 3 to 5 years before we apply for grants. We, as a specialty, have been doing this in surgery for 50 years or more. What else has stayed exactly the same in surgery for 50 years? I really only know of one surgical fellowship that actually incorporates the T32 into the fellowship like most medicine fellowships such as oncology, GI or ID. It's time that surgery steps back and makes a change to advance the careers of our surgeon-scientists. What that will do to our research workforce, how we will populate our labs and how we choose fellows will change. But I honestly think someone a lot smarter than me needs to figure out how we need to train our residents who really want to be surgeon/scientists rather than having them spend two research years for time off for mental health, adding a few papers to their CV to help get their fellowship, moonlighting, and just getting some break in their residency. Our system may have worked fine for 40 years, but if we really want to develop surgeon-scientists, we should change that.

I know as a fourth-year medical student it's hard for you to answer that, so I'll leave that solution to others.

Response from Adishesh Narahari

Thank you, Dr Lillemoe. I think you took the words right out of Dr Schirmer's mouth, and this is the first thing he and I talked about when we were writing this paper is that GYN ONC has a research year built into their fellowship, and a lot of other specialties do that, and they have actually quite high success rates because they only have a year or two between that research time and when they go into junior faculty and apply for them. I'll let you know after my research years as far as what I do with them, but I think you're absolutely right. There needs to be a change to increase the success rate.

Dr. Ronald Dalman (Stanford, CA)

Thanks to the authors for bringing this important question before the Society. Your presentation alluded to the fact that there are several other types of postdoctoral training opportunities available, including NIH T32 and R38 grants, not to

mention VA grants. If your institution has a CTSA, that structure typically provides training grants as well, so the F32 represents only a fraction of the federally-funded postdoctoral training opportunities available to surgical residents.

Interesting to note that compared with its peer surgical specialties, vascular has done relatively well in securing these awards and converting them to principal investigator awards upon completion of training. For full disclosure, I am a vascular surgeon, but, we (the Society for Vascular Surgery) have partnered with the National Heart, Lung, and Blood Institute (NHLBI) for over 30 years to co-fund training grants, so I do think there's some intentionality there.

We fund the professional development time of our integrated vascular residents through our own T32, secured specifically for this purpose. Given the multiplicity of options, the "pipeline" issue you've identified seems to me to be more related to availability of, and competitiveness for, NIH K-awards at the junior faculty level, rather than access to F32s as residents, and how faculty recruitment processes in Departments of Surgery integrate the K award and related professional development requirements into the first term of appointment for junior faculty.

I'd also just point out that I don't think it's coincidental that NHLBI provides the level of funding they do, because both vascular and cardiac surgery have worked hard on this effort. So I think part of the answer to this problem is developing connections with program officers and scientists within targeted institutes to help them understand what our needs are and what our professional development opportunities should be.

Thank you, great presentation.

Response from Adishesh Narahari

Thank you for those comments, and I think there was a paper by Dr Kibbe that highlighted the vascular surgery K-awards and how well they actually do because they're a societal partnership with NHLBI, and we're talking about that, I think, with some faculty members and cardiac surgery as well to do something like that. Thank you.

Dr. John Tarpley (Nashville, TN)

John Tarpley, Vanderbilt, and the Nashville VA. My disclosure is I spent 28 years a VA surgeon. You mentioned other grant sources. Two sources not mentioned are the VA Merit process and the Department of Defense. The VA is an incredible place for the surgeon who wants to focus on surgical education or conduct research. Thank you.

Response: Adishesh Narahari

Thank you.

Dr Mitchell Cohen (Denver, CO)

Hi, Mitch Cohen, Denver, Colorado. Very nicely presented, very important work. I appreciate it. Can you conjecture a little bit, do you think that this is a grant funding problem? I'm hearing my colleagues that there are lots of opportunities out there, and indeed the American College of Surgeons obviously a very long time ago doubled my K award in an attempt to get more people to apply for K's out of trauma, for example, and that mechanism still exists, so it seems like there's adequate opportunity there, so I'm wondering how much of it do you think is the inadequate grant funding opportunity and timing and how much of it is the structural things that Dr Lillemoe and others have suggested that it's just hard to begin a clinical career and an academic career, and while we all get up at these meetings and talk about the importance of science, maybe our profession doesn't echo that as well as it should.

I know that's hard as a fourth-year medical student, but I wonder if there's any data or any discussions you had about where you guys think that that lies and maybe a way to study what those real barriers are because I expect maybe it's not the F grants but rather the structural problem.

Response from Adishesh Narahari

Doctor Cohen, thank you for that important question, so one of the things that we have been discussing at UVA is that the time required to write the grant, apply for the grant, and get it for your two research years is a very limited amount of time, so you really have to write it starting at end of your first-year residency or during your second year to have it fund your two dedicated research years. You have to do this while working and developing the grant-writing skills and having the complexities of writing a grant to do that while you're a second-year surgical resident is extremely difficult, and attendings, I don't know how they do it, but as a future resident, I don't know how I'm going to be able to do it, so we need to look at maybe dedicating some time. I know that Dr Lillemoe at MGH has a couple weeks set aside for residents to do this exact thing, and they give them the resources, the grant-writing classes, the mentorship, to have success when they apply for them, and there are some institutions across the country that are doing that. I think something like that will increase grant funding rates. Some societies such as the American Association of Thoracic Surgeons has workshops as well during their annual meetings where attendings will go, some residents will go, but very rarely is it residents in PGY1 and 2 years that are attending these mentorship sessions to receive help in preparing their grant and finding mentors, so I think I agree with you that there needs to be a standard for getting residents prepared to apply for these grants.

Dr Ronald Dematteo (Philadelphia, PA)

So it was a pretty sobering presentation. What you told us was that on average, 8 surgical residents received an F32 per year over the last 30 years, and less than one in 10 of those individuals goes on to get an RO1 someday. These data could be actually used against us in some ways despite what Dr Zeiger mentioned. I think you highlighted the difficulties that many times the surgical resident is writing the grant before they've even gotten into the lab. I think that actually makes things a little worse because these are some of the more established labs that people are going into because they have the infrastructure to get somebody to write the grant, and frankly, although not required, you generally need RO1-level funding to get someone to have an F32. Therefore, I think we need to do a lot of work here.

It was mentioned by Dr Dalman, but he didn't ask specifically, what happened to T32 funding in surgical departments during this same time period? A T32 puts less stress on the resident to write but also reflects the overall NIH commitment to surgical scientists.

Response from Adishesh Narahari

That's a fantastic question. We actually wrote a paper about T32s a couple years ago. We particularly looked at cardiothoracic surgery residents because of my clinical interests, and we found that institutions that have T32s and have 2 research years, and we compared them to institutions that did not have cardiothoracic surgery T32s, and we did 2 institutions versus 2 institutions, and the ones that have T32s, even the residents that don't go on the T32 end up doing really well because the grant

requires there to be so much rigor and infrastructure at the institution with mentorship, grant-writing, and having established laboratories as well as surgeon-scientists that can lead the T32s, and that is one opportunity to at the institutional level get enough funding to help these residents out.

Dr Benedict Nwomeh (Columbus, OH)

Thanks for that outstanding presentation. I was curious whether you had access to the demographic information on these T32 research residents, which might give us some insight into the characteristics of this, you know, pipeline of researchers and particularly how we might compare it to the internal medicine researchers?

Response from Adishesh Narahari

Absolutely. So the only demographic information we had access to was gender. We also looked at the specialty that they went into, and at some point we also had access to when they graduated from medical school, but beyond that we did not want to evaluate the demographics of these recipients.

Dr Diana Farmer (Sacramento, CA)

Dr Kibbe, the last word?

Dr Melina Kibbe (Charlottesville, VA)

First off, you're doing a fantastic job, especially as a fourth-year medical student, our UVA fourth-year medical student! I want to bring up 2 points. First, I want to echo what Dr Dalman said about SVS. I am a vascular surgeon. The SVS decided to invest in vascular surgeon-scientists - this is not a small thing. It is a very expensive endeavor as they provided match funds for K-awardees. This has been a tremendously successful program, and the SVS is one of only a few societies that do this. So, I would like to encourage many people in this room to work with their societies to establish similar programs.

Second, as pointed out by you and Dr. Cohen, F32s are just not as common in our surgical discipline. T32s are more common. Another really big issue are K-awards in the surgical disciplines. It is costly, because surgeon's salaries are so high, well above the NIH salary cap. There are many departments in this room that can't even afford to support a surgeon on a K aware. That is a real problem for our specialty of surgery. So, here is where I will put out a challenge to Madam President and say that this is a great opportunity for all of our surgical societies to step up and advocate for eliminating the salary cap with the NIH. I would love for the American Surgical to lead the charge and get all of our other societies on board. The NIH salary cap strategically disadvantages all high-compensated disciplines. This is another barrier that limits the pool of surgeons who will pursue careers in science. I would volunteer if the American Surgical ever wanted to take this on because it's that important. Thank you.

Response Adishesh Narahari

Thank you.