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National Institutes of Health Funding in Radiation Oncology: A Snapshot

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Currently, pay lines for National Institutes of Health (NIH) grants are at a historical low. In this climate of fierce competition, knowledge about the funding situation in a small field like radiation oncology becomes very important for career planning and recruitment of faculty. Unfortunately, these data cannot be easily extracted from the NIH's database because it does not discriminate between radiology and radiation oncology departments. At the start of fiscal year 2013 we extracted records for 952 individual grants, which were active at the time of analysis from the NIH database. Proposals originating from radiation oncology departments were identified manually. Descriptive statistics were generated using the JMP statistical software package. Our analysis identified 197 grants in radiation oncology. These proposals came from 134 individual investigators in 43 academic institutions. The majority of the grants (118) were awarded to principal investigators at the full professor level, and 122 principal investigators held a PhD degree. In 79% of the grants, the research topic fell into the field of biology, 13% in the field of medical physics. Only 7.6% of the proposals were clinical investigations. Our data suggest that the field of radiation oncology is underfunded by the NIH and that the current level of support does not match the relevance of radiation oncology for cancer patients or the potential of its academic work force.

Introduction

Biomedical funding in the United States has changed dramatically since 1998. Although the direct costs requested from the National Institutes of Health (NIH) for investigator-initiated research project grants increased from $4.4 billion in fiscal year (FY) 1998 to more than $13 billion in FY 2011, the funds awarded only increased from $1 billion to $2 billion. Only a small portion of this sharp increase in requested funds is caused by an increased number of applications per principal investigator (PI), the main reason being the increasing size of the biomedical workforce (1).

In this environment of fierce competition, an overall knowledge of the funding rate in a small field like radiation oncology/biology/physics becomes crucial. Such information would provide guidance to residency applicants for career planning purposes and support departments in recruiting new faculty. In the analysis described here we have attempted to break down the numbers of NIH support as it pertains to radiation oncology/biology/physics. However, the NIH database merges data for radiation oncology/biology/physics with data for radiology, thus making it difficult to distinguish between NIH funding for radiation vs radiology departments. Therefore, to get a clearer picture of the NIH funding

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landscape in radiation oncology/biology/physics, we decided to manually extract the funding information for radiation oncology/biology/physics from the NIH database and analyze the data to better understand the distribution of NIH grants and awards across institutions.

Methods and Materials

The NIH database (2) was queried. The search was limited to grants awarded to PIs in academic departments listed as "Radiation-Diagnostic/Oncology." Affiliation of individual PIs to radiation oncology departments and/or association of the research topic with radiation oncology/biology/physics were verified using Internet search engines and the project description provided by the PI. For nondisclosed reasons, some institutions (eg, Harvard University, Mayo Clinic, and Memorial Sloan-Kettering) do not list an academic department in their applications. These institutions were left out because the search would have had to rely on PI names listed on the website of these institutions, which may or may not reflect the current body of faculty in a department correctly. Career levels, academic degrees, and the field of study for each investigator were queried from the homepages of the individual institutions.

Descriptive statistics were obtained using the JMP statistical software package (version 10; SAS Institute, Cary, NC).

Results

The query resulted in 952 individual awards, active 10 days after the start of the FY 2013. From these 952 awards, 197 were identified as radiation oncology/biology/physics-related projects. The 197 projects came from 43 academic institutions, all located inside the United States (Fig. 1A and B). These projects were awarded to 134 individual investigators, which results in an average of 1.47 awards per investigator (1 award: n=90 [67.2%]; 2 awards: n=30 [22.4%]; 3 awards: n=10 [7.5%]; 4 awards: n=3 [2.2%]; 5 awards: n=1 [0.7%]) (Fig. 2A). Of all awards, 141 (71.6%) were in year 1-5 of their funding cycle. Fifty-six awards (28.4%) had been renewed 1-4 times and were in funding year 6-25 (Fig. 2B). Eighty-nine (70.1%) of all R01 awards were in year 1-5 of their funding period, 20 (15.7%) in year 6-10, 12 (9.4%) in year 11-15, and 3 (2.4%) in year 16-20 and year 21-25 each.

In terms of academic degree, PhDs were the largest group of investigators funded by the NIH, with a total of 122 PIs, followed by MD/PhDs (48) and MDs (23). In addition, 4 PIs held a DVM, a DVM/PhD, EdD, or an MSEE CCE degree.

The PIs of 118 grants were at the level of full professor, in 49 grants at the level of associate professor, and 27 PIs were at the level of assistant professor at the time of the analysis. Three PIs held a position as a lecturer, postdoctoral scholar, or senior research scientist.

The majority of grants were awarded to radiation biology (n=156, 79.2%); 26 awards (13.2%) had a physics topic, and only 15 awards (7.6%) were clinical investigations. In projects related to radiation biology, 98 PIs (62.8%) held a PhD, 45 (29.2%) an MD/PhD, 11 (7.1%) an MD degree, and 2 (1.3%) a DVM or DVM/PhD degree. Projects related to medical physics were led by 23 PIs (88.5%) holding a PhD, 1 (3.8%) an MD/PhD, 1 (3.8%) an engineering degree, and 1 (3.8%) a dosimetry degree. Out of 15 PIs of the clinical projects, 12 (80%) held an MD, 2 (13.3%) an MD/PhD, and 1 (6.7%) a PhD degree.

Only 18 institutions had 3 or more investigators with active NIH funding, with an average of 1.52 (range 1-3) grants per investigator. The NIH-funded research program of 25 institutions relied on 1 or 2 investigators.

The total amount of active NIH funding for radiation oncology/biology/physics projects for FY 2013 was $85,511,067 (direct plus indirect costs), with an average award size of $449,294 ± $537,065.50. The majority of awards were granted through the R01 (n=126) and R21 (n=26) funding mechanisms

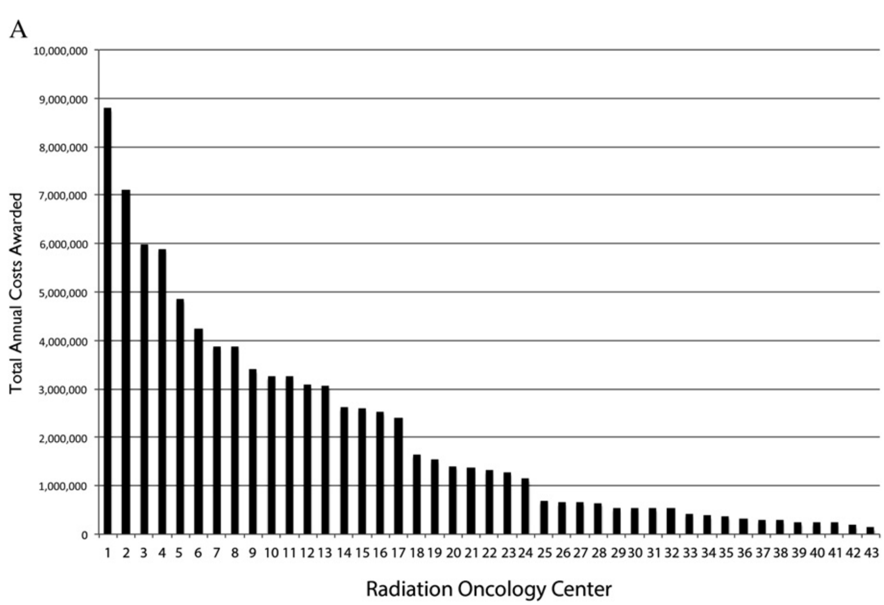


Fig. 1. (A) Ranking of US radiation oncology centers based on total active funding from the National Institutes of Health at the beginning of fiscal year 2013. (B) Number of National Institutes of Health awards and number of principal investigators (PIs) per institution at the beginning of fiscal year 2013.

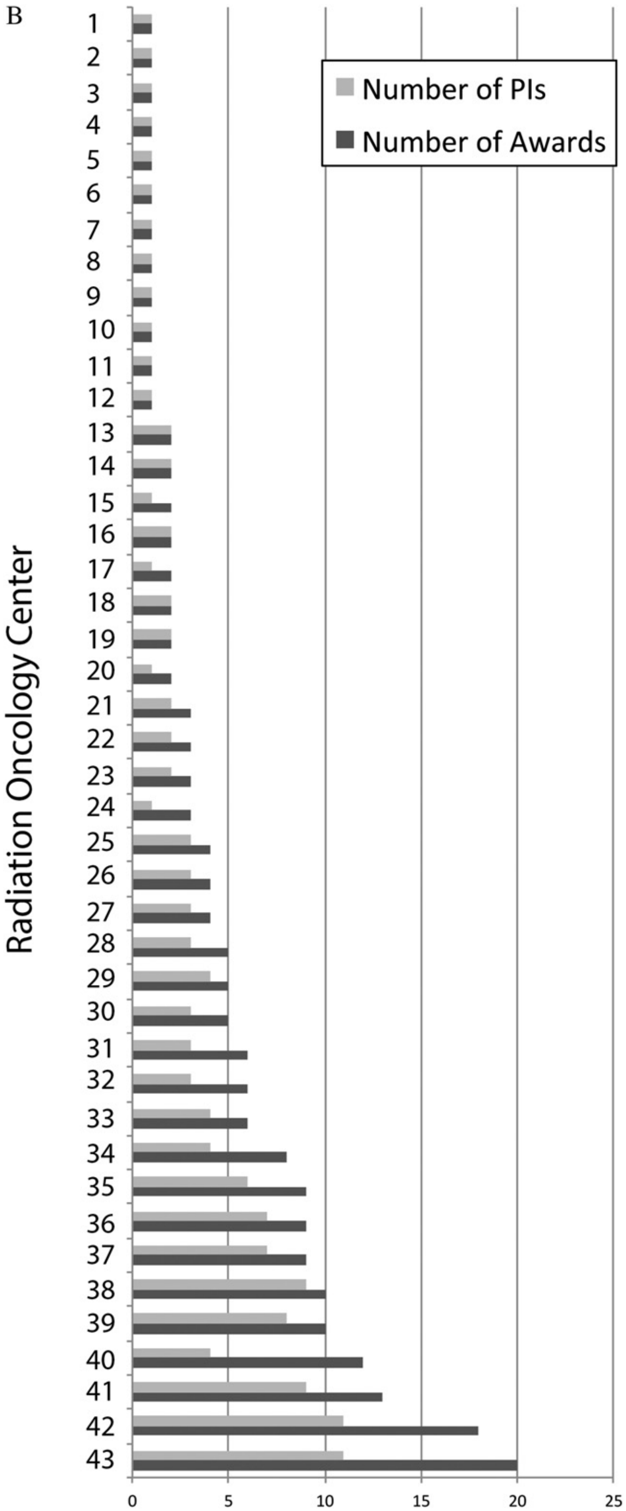
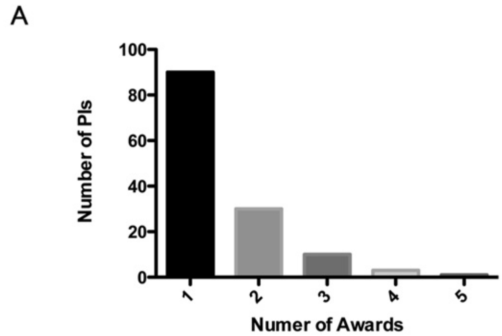


Fig. 1. (*continued*)

(Fig. 3A). More than two-thirds (76.9%) of the monetary NIH support granted for radiation research was awarded through the R01 (46.1%), U19 (16.4%), P01 (7.7%), and R21 (6.7%) funding mechanisms (Fig. 3B). Administrative supplements were granted for 5 awards (1 K01, 1 P01, 2 R01s, and 1 U24). A total of 22 applications (11.2%) were funded after resubmissions (A1). A list



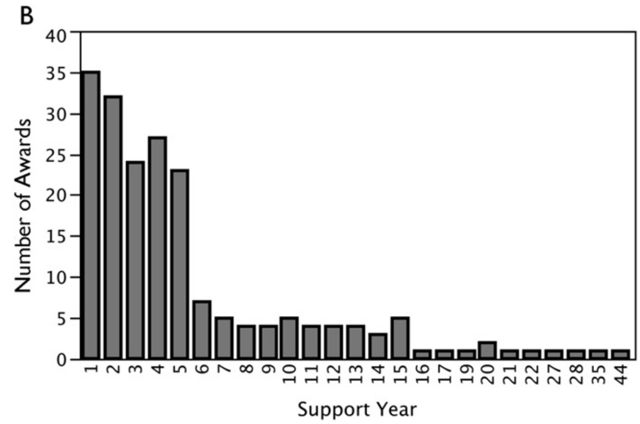


Fig. 2. Distribution of principal investigators (PIs) in radiation research with 1 to 5 National Institutes of Health awards. (A) A total of 134 individual investigators were awarded 197 grants, resulting in an average of 1.47 awards per investigator (1 award: n=90 [67.2%]; 2 awards: n=30 [22.4%]; 3 awards: n=10 [7.5%]; 4 awards: n=3 [2.2%]; 5 awards: n=1 [0.7%]). (B) Distribution of the current funding year for all active awards at the beginning of fiscal year 2013. Of all awards, 141 (71.6%) were in year 1-5 of their funding cycle.

with a description of the different grant types awarded to radiation oncology departments is given in Table 1.

A total of 151 grants (76.7%) were awarded by the National Cancer Institute (NCI), 10 (5.1%) by the Office of the Director, 7 (3.6%) by the National Institute of Environmental Health Sciences, 6 (3%) by the National Institute of General Medical Sciences, 5 (2.5%) by the National Institute of Allergy and Infectious Diseases, 4 (2%) by the National Institute of Neurological Disorders and Stroke, 3 (1.5%) by the National Institute of Biomedical Imaging and Bioengineering, 2 each (1%) by the National Heart, Lung, and Blood Institute and the National Institute of Dental and Craniofacial Research, and 1 (0.5%) each by the Fogarty International Center, the National Center for Chronic Disease Prevention and Health Promotion, the National Center for Research Resources, the National Human Genome Research Institute, the National Institute of Arthritis and Musculoskeletal and Skin Diseases, the National Institute of Child Health and Human Development, the National Institute of Diabetes and Digestive and Kidney Diseases, and the National Institute of Mental Health (Fig. 4).

The average (±SD) award size for R01s was $321,204 (n=127, ±$282,705), for U19s $2,999,389 (n=5, ±$2,656,449.50), for P01s $1,368,512 (n=5, ±$835,452), and $228,744 for R21s (n=26, ±$188,538) (Fig. 5).

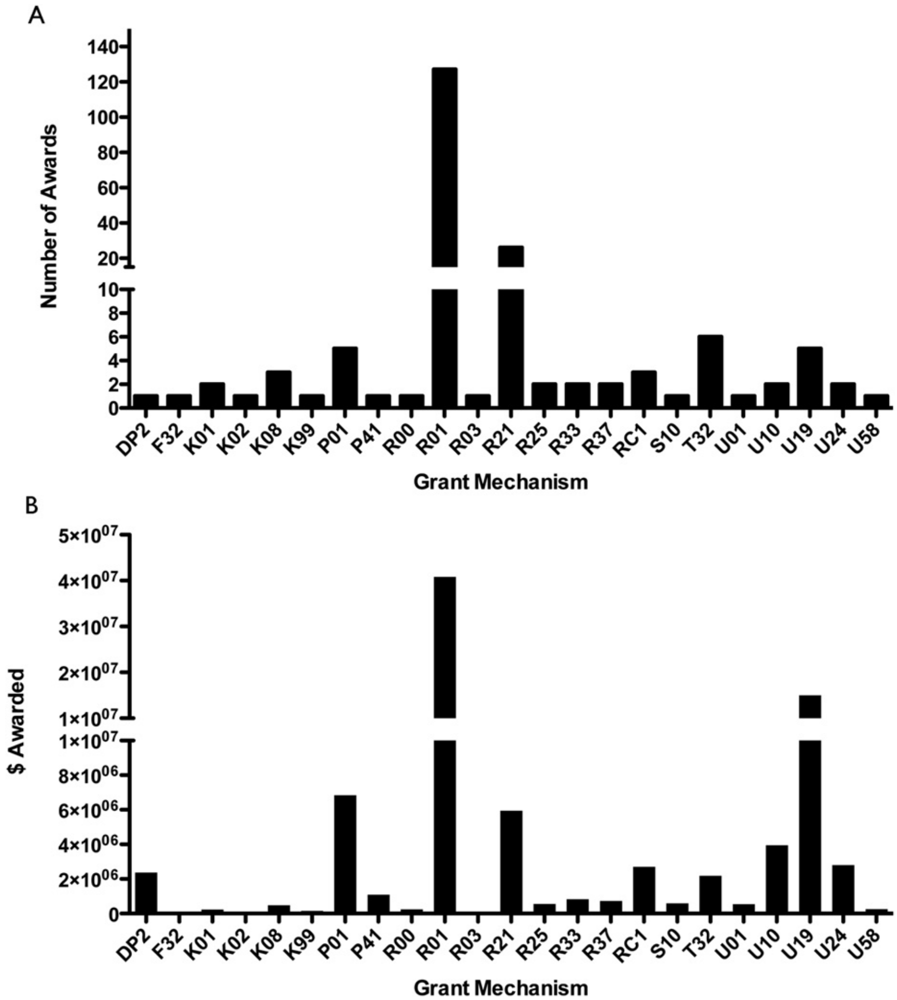


Fig. 3. Distribution of all awards between the different award mechanisms (A) and total annual costs (B). More than two-thirds (76.9%) of the National Institutes of Health support granted for radiation research was awarded under the P01, R01, R21, and U19 mechanisms.

R01 and R21

Sixty (30.5%) of all grants were awarded through the Radiation Therapeutics and Biology (RTB) study section. Fifty-four (90%) of these 60 applications were submitted under the R01 funding mechanism (including 1 supplement). Seventy-four awards (37.5%) resulted from review through special emphasis panels, of which 31 (41.9%) where R01 applications. This indicates that at least 33% of all R01 applications in radiation oncology/biology/physics were awarded through study sections other than RTB.

In the RTB study section 5 R01s (9.4%) and 1 R21 applications were awarded as A1 applications (applications that had been previously reviewed, revised, and resubmitted), whereas 10 (16.1%) of the 62 R01 parent applications awarded through study sections other than RTB were awarded as A1 applications. Only a total of 4 (15.4%) of 26 R21 applications were awarded through the RTB study section.

Individual training grants

At the time of the analysis 1 F32, 2 K01 (Mentored Research Scientist Development Award, NCI participates), 1 K02 (Independent Scientist Award, NCI does not participate), 3 K08 (Mentored Clinical Scientist Development Award, NCI participates), 1 K99, and 1 R00 were active (Pathway to Independence Award, NCI participates).

Center grants

We identified 1 active DP2 award, 5 P01 grants (4 parent grants and 1 supplement), 1 P41 award, 6 T32 awards (including 1 supplement), 1 U01 award, 1 U10 award, 5 U19 awards, 2 U24 awards (including 1 supplement), and 1 U58 award. The T32 awards covered cancer prevention, postdoctoral education in radiation science, radiation biology and free radicals, and radiation oncology translational research.

Discussion

As of December 2012 the Accreditation Council for Graduate Medical Education listed 87 academic programs in radiation oncology (3). Academic radiation oncology departments are in general small departments relative to other departments within the medical school, with a relatively small body of faculty. However, it was surprising that only 43 (49.4%) of all accredited

Table 1 Grant types awarded to radiation oncology departments

Funding mechanism	Title	Description
DP2	NIH Director's New Innovator Awards	To support highly innovative research projects by new investigators in all areas of biomedical and behavioral research.
F32	Postdoctoral Individual National Research Service Award	To provide postdoctoral research training to individuals to broaden their scientific background and extend their potential for research in specified health-related areas.
K01	Research Scientist Development Award—Research and Training	For support of a scientist, committed to research, in need of both advanced research training and additional experience.
K02	Research Scientist Development Award—Research	For support of a scientist, committed to research, in need of additional experience.
K08	Clinical Investigator Award	To provide the opportunity for promising medical scientists with demonstrated aptitude to develop into independent investigators, or for faculty members to pursue research aspects of categorical areas applicable to the awarding unit, and aid in filling the academic faculty gap in these shortage areas within health profession's institutions of the country.
K99	Career Transition Award	To support the initial phase of a Career/Research Transition award program that provides 1-2 years of mentored support for highly motivated, advanced postdoctoral research scientists.
P01	Research Program Projects	For the support of a broadly based, multidisciplinary, often long-term research program, which has a specific major objective or a basic theme. A program project generally involves the organized efforts of relatively large groups, members of which are conducting research projects designed to elucidate the various aspects or components of this objective. Each research project is usually under the leadership of an established investigator.
P41	Biotechnology Resource Grants	To support biotechnology resources available to all qualified investigators without regard to the scientific disciplines or disease orientations of their research activities or specifically directed to a categorical program area.
R00	Research Transition Award	To support the second phase of a Career/Research Transition award program that provides 1-3 years of independent research support (R00) contingent on securing an independent research position.
R01	Research Project	To support a discrete, specified, circumscribed project to be performed by the named investigator(s) in an area representing his specific interest and competencies.
R03	Small Research Grants	To provide research support specifically limited in time and amount for studies in categorical program areas.
R21	Exploratory/ Developmental Grants	To encourage the development of new research activities in categorical program areas.
R25	Education Projects	For support to develop and/or implement a program as it relates to a category in one or more of the areas of education, information, training, technical assistance, coordination, or evaluation.
R33	Exploratory/ Developmental Grants Phase 2	The R33 award is to provide a second phase for the support for innovative exploratory and development research activities initiated under the R21 mechanism.
R37	Method to Extend Research in Time (MERIT) Award	To provide long-term grant support to investigators whose research competence and productivity are distinctly superior and who are highly likely to continue to perform in an outstanding manner.
RC1	NIH Challenge Grants and Partnerships Program	NIH Challenge Grants in Health and Science Research
S10	Biomedical Research Support Shared Instrumentation Grants	To make available to institutions with a high concentration of NIH extramural research awards, research instruments which will be used on a shared basis.
T32	Institutional National Research Service Award	To enable institutions to make National Research Service Awards to individuals selected by them for predoctoral and postdoctoral research training in specified shortage areas.

(*continued on next page*)

Table 1 (*continued*)

Funding mechanism	Title	Description
U01	Research Project—Cooperative Agreements	To support a discrete, specified, circumscribed project to be performed by the named investigator(s) in an area representing his specific interest and competencies.
U10	Cooperative Clinical Research—Cooperative Agreements	To support clinical evaluation of various methods of therapy and/or prevention in specific disease areas.
U19	Research Program—Cooperative Agreements	To support a research program of multiple projects directed toward a specific major objective, basic theme or program goal, requiring a broadly based, multidisciplinary and often long-term approach.
U24	Resource-Related Research Projects—Cooperative Agreements	To support research projects contributing to improvement of the capability of resources to serve biomedical research.
U58	Chronic Disease Control Cooperative Agreement	In cooperation with state and local public health agencies and other public or private organizations to assist in controlling and preventing chronic diseases.

Abbreviation: NIH = National Institutes of Health.

academic programs in radiation oncology have an active research program that is supported by NIH grants, considering that radiation oncology academic departments have, for a number of years, attracted the top tier of medical school graduates, with the highest percentage of MD/PhDs into its residency programs (4).

A study in 2009 investigating the scholarly productivity of 78 academic programs in radiation oncology identified 826 radiation oncology physician-scientists in 2007, not including physicists and basic science researchers (5), and it is likely that this number did increase over the last 5 years. With 134 PIs including physicians, physicists, and biologists in radiation oncology funded by the NIH at the time of the present analysis, it seems that only approximately 1 in 10 of all faculty in academic radiation oncology programs currently receives NIH research support. The NIH currently supports investigators with $30.9 billion annually through more than 50,000 grants, with an estimated $5.4 billion spent on cancer in FY 2013. This suggests that less than 0.3% of NIH-funded PIs are working in the field of radiation oncology, and radiation oncology secures only 1.6% of the funding provided for cancer research by the NIH.

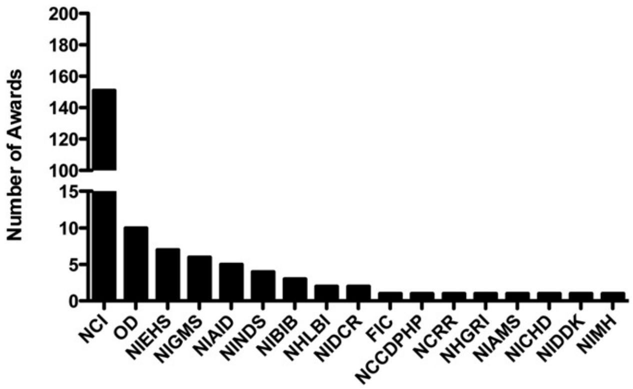


Fig. 4. Distribution of all awards in radiation by National Institutes of Health institutions. Institution acronyms are spelled out in text (Results).

Even though there is no clear definition of a "critical mass" for research groups, it is obvious that very small groups are constantly at risk of losing all NIH support through mobility or retirement of faculty and an increasingly difficult funding environment. In 25 (53.7%) of the institutions, the NIH-funded research program could be considered unstable, with only 1 or 2 faculty carrying the program. Eleven institutions had 3 or 4 NIH-funded investigators, and only 7 institutions had more than 5 NIH-funded investigators, with 4 of these programs ranking within the top 10 in total funding.

The majority of support from the NIH for radiation research projects was awarded under the R01 funding mechanism. Only 30% of all R01s had been awarded as competitive renewals. Given the current initial administrative cuts to R01s, combined with additional annual reductions and limitation of the annual budget of renewal applications based on the annual budget of the previous

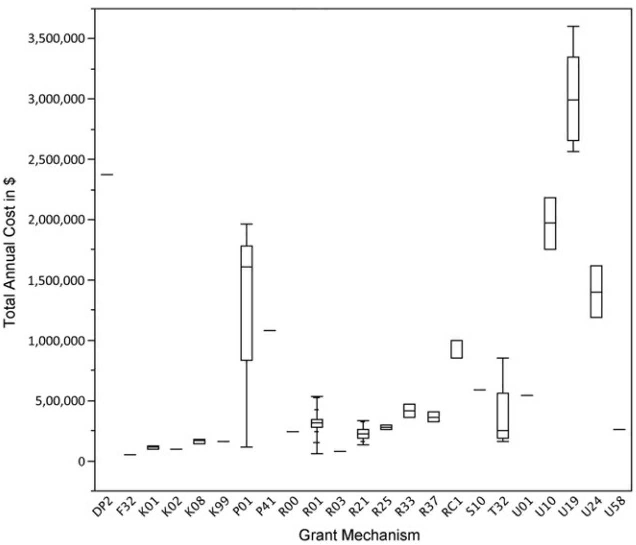


Fig. 5. Average total annual costs of grants awarded to radiation research at the beginning of fiscal year 2013, by award mechanism.

award's last year budget, competitive renewal application rates will most likely drop even further, thus jeopardizing the establishment of long-term programs.

At the time of the analysis only 26 R21 awards were active. This may be in part due to the fact that until recently the NCI did not offer funding for investigator-initiated projects under this mechanism. Now, with the NCI participating in this program, the number of R21s may rise in the near future.

The relatively low number of grants (60) awarded after review by the RTB study section may have several reasons: first, RTB does not exclusively review radiation oncology proposals. Second, radiation oncology is a small field, and with the small number of PIs in radiation oncology currently funded by the NIH, conflicts of interest occur frequently and many applications are reviewed by special emphasis panels.

It was concerning to find only 9 active career development awards, 3 of which were K08 (Mentored Clinical Scientist Development Award). Given the consistently top-ranking medical school graduates with advanced degrees in radiation oncology residency programs, one would expect that this group would be highly competitive when applying for K08 awards.

The recent addition of Centers for Medical Countermeasures Against Radiation has boosted radiation research in the United States substantially and has attracted a large number of PIs from outside radiation oncology departments into the field of radiation research. However, continuation of this program is not guaranteed, and its elimination would have a major negative effect on a field that is ostensibly underfunded.

This study has several limitations. First, the NIH data set is incomplete because some institutions do not list an academic department in their application, and those programs were not included in this analysis. However, on the basis of the faculty listed on the websites of these programs and funding allocated to these PIs in the NIH database, inclusion of these programs would not change the overall picture of the NIH funding landscape in radiation research (total annual NIH funding for radiation oncology at Mayo Clinic $721,087; Memorial Sloan-Kettering $1,682,565; Harvard University $3,862,981). Second, thematic overlap in radiation physics between radiation oncology and radiology made it hard to register projects to one of the specialties if the home department for radiation oncology and radiology is a center in which both departments are not clearly separated. Third, this study is only a snapshot of NIH funding, which is a moving target and has certain fluctuations during the funding cycles. Fourth, radiation research grants with multiple PIs in which the leading PI does not belong to a radiology/radiation oncology program were not included. Finally, our study did not include other major funding sources like the Department of Defense, National Aeronautics and Space Administration, Biomedical Advanced Research and Development Authority, Department of Energy, and the National Science Foundation. At this point, data from these funding sources are not as easily available as data from the NIH. However, despite the incomplete nature of the available data, our study strongly suggests a dire funding situation for a specialty that treats approximately 60% of all cancer patients in the United States (6).

Our study indicates an urgent need to separate radiation oncology data from radiology in the NIH database. Adequate reporting, either within the NIH database or performed by external oversight, should have sufficient granularity and specificity to allow for clarity regarding funds flow and allocation. In addition, this analysis highlights enormous underutilized potential: (*1*) physician scientists are the largest group of academic faculty; however, they are underrepresented in the group of NIH-funded PIs in radiation oncology. One plausible reason for such a discrepancy might be the allocation of compensation plans, which favor clinical practice over academic accomplishments. This apparent lack of academically active physician scientists raises significant concern regarding translation of basic science results into clinical practice; (*2*) A large number of programs do not have a "critical mass" of NIH-funded scientists in their research programs and may not be sustainable in the current and future funding environments; and (*3*) The potential of the many outstanding residents is widely underutilized.

Policies within the specialty of radiation oncology, and by the NIH, should address these foundational issues. In the long run, more physician scientists should compete for NIH awards; however, they will need to be enabled by new NIH policies promoting clinical translation in radiation oncology. Academic radiation oncology programs should strongly encourage applications for K-type career development awards. However, it must be pointed out that although basic scientists go through years of training that includes honing of grant-writing skills, medical students and residents in radiation oncology in general lack this experience. Therefore, academic radiation oncology programs should provide appropriate grant-writing training and support, as well as mentoring, to allow residents and junior faculty to successfully compete for grant support in a climate of fierce competition.

The overall state of NIH funding in radiation oncology raises great concern. Many academic radiation oncology departments have already become "service" departments, where novel research is limited and little or no translational efforts occur.

A significant number of programs, although currently still funded by the NIH, are at risk of the same fate, unless substantial investment into translational and basic science research occurs within these programs. For significant change to take place, funding through federal sources supplemented institutionally and by the private sector is a necessity. In the future, significant clinical advancement in the field of radiation oncology will likely result from insights gained through basic science research, with the potential to be translated to the patient in the clinic in radiation oncology departments with strong clinical translation programs. Radiation oncology must activate the quiescent academic potential of its current and emerging basic and physician scientists or risk the senescence of the field and its relevance to the new cancer treatment strategies of the future.

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