Policy Implications of Aging in the NIH-Funded Workforce

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Because of national interest in the "graying" of the biomedical workforce, we examine aging and funding within the pool of NIH-funded investigators and applicants, particularly in the growing field of stem cell research. We provide evidence of a maturing and more competitive stem cell workforce and discuss policy implications.

The biomedical research workforce is aging. This well-known fact has been discussed by NIH leadership (https://nexus.od.nih.gov/all/2015/03/25/age-of-investigator/ and https://nexus.od.nih.gov/all/2012/02/13/age-distribution-of-nih-principal-investigators-and-medical-school-faculty/), members of Congress (http://www.nytimes.com/2014/10/03/opinion/young-brilliant-and-underfunded.html?_r=2), and extensively within extramural research communities throughout the United States (Butz, 2004; DeLong, 2004; Buerhaus et al., 2000). Management experts have spent the past few decades discussing the aging U.S. workforce and important topics such as the critical role of knowledge transfer (Calo, 2008; Rappaport et al., 2003). While national discussions take place on the aging and funding of the entire biomedical research workforce, we know little about trends within subspecialties. To help understand broad overarching themes, as well as more specialized area trends, we focus on NIH investigators in general and those engaged specifically in stem cell research (see Supplemental Information for detailed explanations of criteria for our analysis).

Our preliminary analysis suggests that the collective aging of the NIH-funded independent investigator workforce is not solely the product of any policy or mechanism. Rather, it is an accumulation of multiple factors including a shift in perceptions, expectations, and the general structure of the extramural workforce, as well as global macroeconomic factors. Based on a comparison of the ratio of award to applicants by age group, we find no clear evidence that the NIH-funded independent investigator workforce is aging solely because of competitiveness in a limited resource market. While the funding and purchasing power of NIH research grants have fluctuated over time for all NIH-funded research, the proportion or rate of applicants funded during times of limited resources (e.g., post-2003) is relatively similar in older applicants compared to younger ones. Table 1 (All Researchers) and Figure 1 (All Researchers) highlight this fact. While age and experience may be correlated, Mincer (1974) showed that experience influences income and returns to education more than age. The same might be true for other sources of income, particularly funding for one's research. If age does imply more experience, as funding restricts, we would expect to see a higher proportion of older established investigators funded. We do not see this, which could imply that experience is not highly correlated with age, that experience is more of a predictor of scientific funding than age, or that specific policies focused on early-stage investigators is mitigating some of the effect, among other possible reasons.

Growth of an Aging Stem Cell Research Workforce

For NIH overall, funding rates were relatively similar among age groups during the period we examined. However, the number of both awardees and applicants grew at a faster rate in older age groups than in younger age groups between 2005 and 2014.

Stem cell research is a relatively new field within the almost century-long history of NIH-funded scientific research. In stem cell research, NIH R01-equivalent investigator applicants who were aged 60 to 64 grew by almost 5-fold (469.8%) between 2005 and 2014, with awardees increasing by more than 2-fold during that time period (240.0% growth, Figure 1). For all of NIH, the growth in investigator applicants between 2005 and 2014 for the same age group was 39.9% (with 30.4% growth in awardees Figure 1). Applicant growth rates for both stem cell and all research over the same period was greatest for those aged 70 plus (554.5% and 110.1% respectively, Figure 1).

While the growth in applicants was fastest in the older age groups, the NIH-funded stem cell research workforce also saw growth in the number of principal investigators under age 50 between 2005 and 2014. The number of investigators funded grew by 80.4% for those aged 40–44 and 32.8% for those aged 45–49 (Figure 1). The number of all NIH R01-equivalent awardees during that same period shrunk by 9.5% for those aged 40–44 and by 22.2% for those aged 45 to 49 (Figure 1).

Gender and Independence under Age 40

In the 1980s, more individuals under the age of 40 applied for an R01-equivalent award than today, and, over the years, the number of awardees and applicants

Table 1. NIH Funding Rates for Independent Investigators (R01-Equivalent) by Type of Research and Age Group, 1980–2014

	Age Group	1980	1990	2000	2005	2010	2014
Stem Cell Researchers	<35	—	—	^	^	^	^
	35–39	—	—	100.0	17.4	18.4	21.6
	40–44	—	—	100.0	30.7	16.7	18.3
	45–49	—	—	100.0	36.9	17.1	17.6
	50–54	—	—	100.0	23.2	18.4	13.7
	55–59	—	—	^	28.6	17.6	13.4
	60–64	—	—	^	23.3	26.5	13.9
	65–69	—	—	^	^	16.3	20.9
	70+	—	—	^	^	^	18.1
	TOTAL	—	—	100.0	28.9	17.8	16.5
All Researchers	<35	46.1	29.7	28.0	24.2	22.3	19.2
	35–39	48.7	29.9	34.4	24.6	27.3	24.8
	40–44	48.8	33.1	35.6	26.0	25.9	23.6
	45–49	50.9	34.2	37.6	28.5	25.2	22.9
	50–54	52.4	32.4	39.4	28.3	27.6	23.7
	55–59	53.7	34.4	38.4	28.5	27.3	24.5
	60–64	45.0	34.7	36.9	26.9	29.0	25.1
	65–69	51.3	31.1	36.1	25.9	25.7	23.0
	70+	^	33.3	30.9	26.4	22.4	22.6
	TOTAL	49.0	32.3	36.6	27.2	26.5	23.7

(^), not reported due to small cell size. (—), data unavailable.

under age 40 has decreased (Figure S1B). For investigators under age 40, gender differences in both application and award exist over time. Fewer male investigators under age 40 apply now for R01-equivalent grants compared to the 1980s and 1990s (Figure S1B) and, in tandem, are receiving fewer awards. Women under age 40, however, have increased their applications since 1980 and the number awarded has remained relatively stable.

For stem cell researchers, the field is relatively new and the number of independent investigators under age 40 grew during the period from 2000 to 2010 (Figure S1A). The number of applicants under 40 declined between 2010 and 2014 for both men and women. However, the number of awardees increased slightly during that time period for women, while declining slightly for men.

Increased Competition for NIH Funding in Stem Cell Research

Along with a major expansion of the stem cell research workforce over the past few decades, there has been a decrease in funding rates (Table 1). As the field grew and expanded, competition increased. In 2000, NIH funded all stem cell research applications submitted. By 2005, the NIH funded only about one-third of all proposed stem cell research projects, and, by 2014, it funded only one-sixth of proposals. The funding rates for stem cell researchers today are more competitive than the entire NIH research workforce pool where in 2014 NIH funded around one in four R01-equivalent investigators overall (Table 1).

Factors outside the Direct Control of Funding Agencies

The R01-equivalent principal investigator workforce has been aging. While funding rates have decreased over time (Table 1, see All Researchers), the funding rates are decreasing at relatively similar rates for all age groups. At the same time, the growth in applicants is highest among older investigators. These facts suggest that changes outside of the NIH-controlled mechanism are influencing how and when investigators choose to apply for an independent research award. If anything, the fact that NIH has had numerous programs in place over the years to support new investigators could imply that without those programs, we could be seeing an even larger reduction in young investigators awardees.

The way institutions structure funding for the academic research workforce has undergone major changes. More and more academic medicine institutions and research universities rely on federal grants and other funding to partially sponsor faculty salary and soft money positions. Soft money positions depend on funding availability, making the investigator's position rely heavily on the ability to write successful grant applications of high quality that align with the priorities of the funding organization. This shift from tenure and tenure-track positions paid by institutions toward those relying on grant awards to partially fund salary has greatly changed the academic medicine environment over the past five decades. As positions become more dependent on external funds, individuals spend more time in training and in preparation for the transition to independence.

Biomedical research today is international. In 1980, non-citizen biomedical researchers made up only 5.3% of the biomedical research workforce in the U.S., but grew to up to 24.6% of the workforce by 2010 (authors' calculations using Ruggles et al., 2015). Not only is the U.S. biomedical research workforce more international than ever before, other countries are increasing investments in biomedical research. From 2007 to 2012, China's investment in biomedical R&D spending increased by 32.8%, while the U.S. biomedical R&D spending decreased by 1.9% after adjusting for inflation (Chakma et al., 2014). International flows of biomedical researchers in and out of the U.S. today have implications for understanding the aging workforce. These factors and the others mentioned above require a comprehensive examination of the current system, including incentives and disincentives related to funding and institutional support both within the U.S. and abroad.

NIH Retirement Age Replacement Ratio

An aging workforce needs to be monitored in order to plan adequately for the future. Being overly dependent on a workforce over age 65 (the U.S. retirement age) makes the workforce vulnerable to high

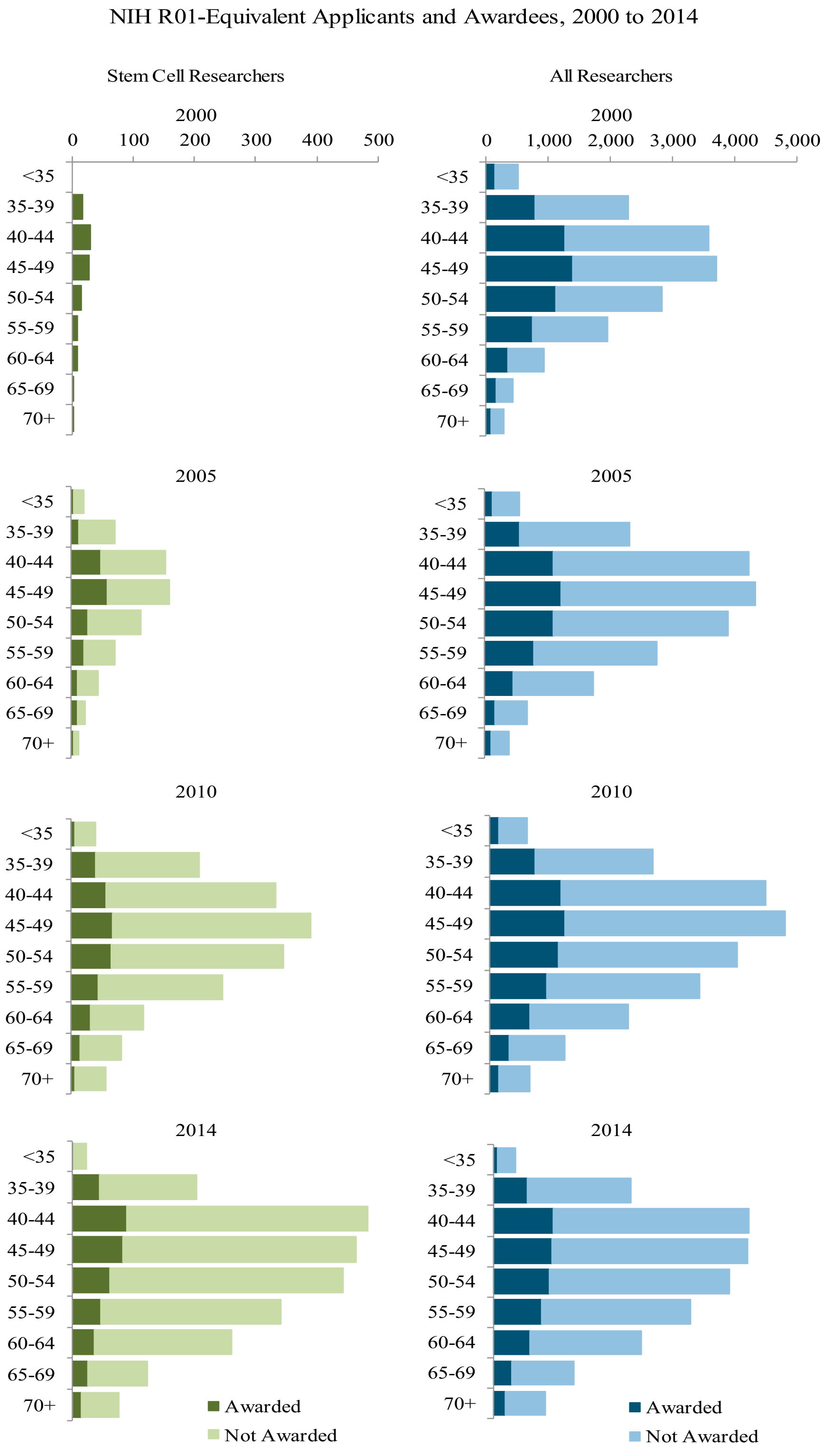

Figure 1. Independent Investigators (R01-Equivalent) Applicants and Awardees by Type of Research and Age Group 2000 to 2014

exit rates within upcoming years and intensifies the need to potentially fill multiple positions quickly. In biomedical science where training requires years of investment, the ability to replace an older workforce requires the precise ability to forecast and understand how many positions we must fill 6 to 10 years from now.

To illustrate our point, we developed and calculated an NIH retirement age replacement ratio for R01-equivalent principal investigators (Lee, 2003; see Supplemental Information for equation and explanation of calculations) and examined trends from 1980 to 2014 for both NIH-funded stem cell awardees and all NIH-funded awardees.

This ratio reflects the NIH-funded workforce that is over age 65 and would need to be replaced by those age 65 and younger in order to maintain the workforce at the same level. This ratio has been increasing rapidly over the past four and a half decades. While less than 1% in 1980 for both men and women combined, by 2010 it had increased to more than 10% of the NIH-funded workforce under age 65 (Figure S2). This implies that if all independent investigators aged 65 plus were to retire tomorrow, NIH would need to increase its workforce under age 65 by 10% in order to maintain the same number and level of research it currently funds today. As shown in Figure S2, NIH-funded stem cell investigators have similar replacement ratio trends.

We know successful independent biomedical researchers have long careers and many continue working beyond age 65. Figure S2 also shows the retirement age replacement ratio with a cutoff at age 70. If we assume that investigators exit the system around age 70 instead of age 65, the replacement ratio decreases from 0.102 to 0.037 in 2014, implying an immediate or short-term need to replace around 4% of investigators under age 70. For stem cell investigators, the rate goes from 0.090 to 0.033 in 2014.

Planning for the Future

The age pyramids (Figure 1) and retirement age replacement ratios (Figure S2) demonstrate key indicators that help us monitor an aging workforce. By using such tools, we are able to better equip ourselves with the knowledge needed to strategically plan for replacement as needed or desired. As we have shown, these tools can be used to understand the overall biomedical workforce, as well as specialized areas, such as stem cell research.

Our analysis hints at the fact that demographic changes, external environmental factors, and advances in research areas (such as the growth of stem cell research) influence the age composition of the workforce, along with budgetary realities. The U.S. biomedical research workforce has grown over the past four and a half decades, and the stem cell research workforce has blossomed. While the rate of attaining a Ph.D. for the baby boom cohort is less than today's generation, the expanded population of researchers greatly increased the population of graduate and postdoctoral trainees looking for independent research positions. As the baby boom generation slowly ages out of the system, they will continue to be replaced by their younger cohorts of trainees who made a career in science and are now independent investigators.

The workforce is aging. Our analysis and evidence suggests that any NIH intervention can only have a limited impact. Even if we increase funding for early career investigators, influencing their ability to stay in science in their early careers, those investigators need long-term sustainable jobs at academic or research institutions and will need continued future independent investigator funding as they advance in their careers. Even if we offer early retirement packages, this will only make an impact on the margin, moving a handful of those who are considering retirement but not ready to actually retire with the possibility of moving into retirement with additional incentives. Policy interventions can have a limited impact in the short run. However, when considering policy interventions, it is essential to consider not only short-term solutions, but also the long-term consequences of those interventions.

The stem cell research workforce has expanded over the past decade and a half. Even though it is a "relatively" new field given NIH's history, it faces some of the similar issues experienced by the entire research community. It is also aging. The number of NIH R01-equivalent applications from older stem cell investigators has been growing at a faster rate than younger investigators and competition for funding is intense. However, retirement-age replacement ratios are increasing. As with the entire biomedical research workforce, stem cell researchers who are dependent on NIH for research funding will also have to examine the culture and environment in their institutions and work with federal agencies and other funders to find creative and innovative solutions to help reduce the stress on an aging workforce system within a limited-resources environment.

SUPPLEMENTAL INFORMATION

Supplemental Information for this article includes analysis criteria and calculations and two figures and can be found with this article online at http://dx.doi.org/10.1016/j.stem.2016.06.012.

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WEB RESOURCES

The URLs for data presented herein are as follows:

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