

The Gender Gap in NIH Grant Applications

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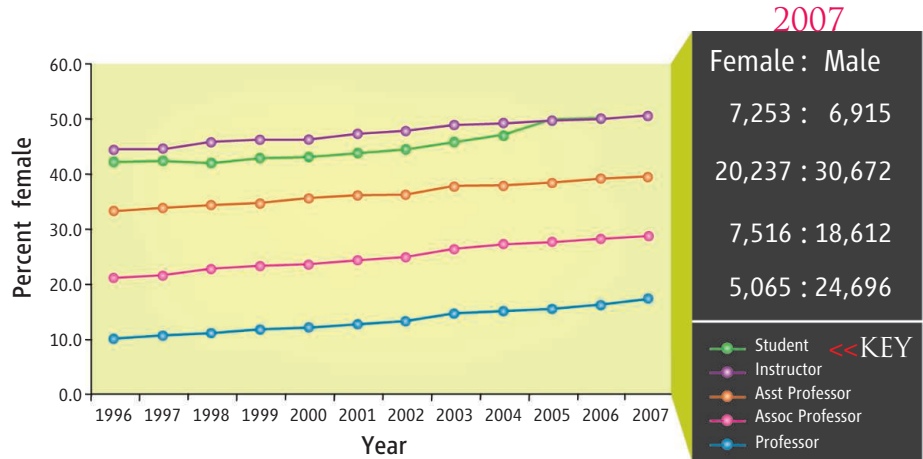
Many reports over the past two decades have drawn attention to the paucity of senior female faculty in American medical schools and universities [for recent examples, see refs. (1–5)]. As the career pipeline progresses for biomedical scientists in U.S. medical schools, there is excess attrition for women (see figure, right). However, at the beginning of the pipeline, gender parity exists for M.D.'s and Ph.D.'s. In this report, we use a data-driven approach to better understand when and why this attrition occurs.

In 2005, 49% of the 6368 Ph.D.'s awarded in the biological sciences went to women (6). Gender equity has also recently been achieved for medical school students (49% of 17,826 students admitted in 2007 were women) (7). Instructors at medical schools (51% female in 2007) reflect this gender parity, but there is a striking drop in the percentage of women who are assistant professors (39%), associate professors (25%) and full professors (17%) (8); all of these differences are statistically significant ($P < 0.001$ for each career stage to the next, by using 2007 data).

Slow improvement in the percentage of women at each of the stages in the career path is evident over the past two decades, but the rate of change is parallel to the increased proportion of female medical students. This suggests that the increase in women at later stages of the pipeline is the consequence of a slow “pull” provided by the expanding pool of women at the beginning of their medical studies—not because of an effective “push” that reduces attrition during career advancement, which would be expected to change the slope of the lines.

Many studies have recently evaluated this issue and have suggested reasons why this career attrition may be occurring (1–5, 9–14). However, gender-specific National Institutes of Health (NIH) grant application rates have thus far been examined only at a single university at different times in the career

Many qualified women scientists stop applying for NIH grants in the late postdoctoral and early faculty years.

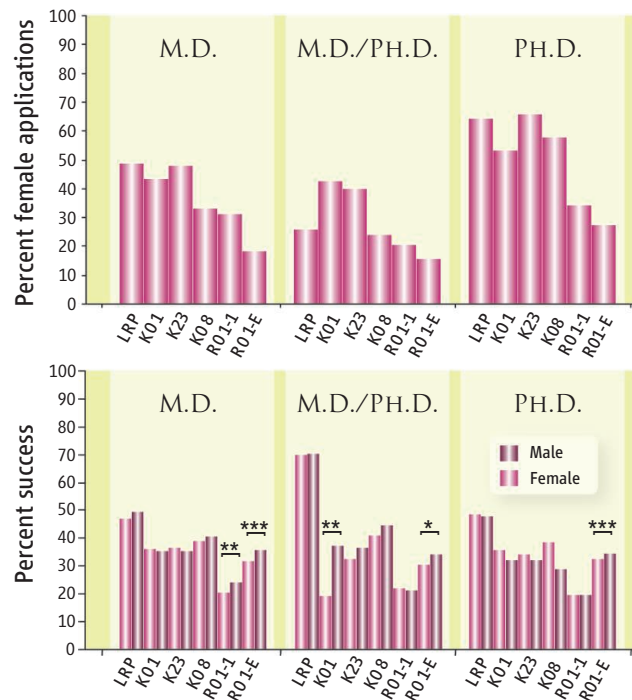


Trends in the percentages of female students and faculty in medical schools. For female medical students; female medical school instructors; and assistant, associate, and full professors. Data for each academic rank from 2007 are shown on the right.

path (14). For this reason, we obtained data from NIH to define the gender of each grant applicant and to determine the funding success rates for specific grant types that reflect different stages in the careers of biomedical scientists. Further, we have evaluated these data in the context of the degrees held by the applicants, because people with different training

backgrounds apply for different types of grants. Because recent studies have suggested that attrition might be particularly severe when female scientists are on the bridge to independence (13, 14), we specifically included several grant types that reflect this career stage, including Loan Repayment Program awards (LRPs) and mentored K series awards.

Loan Repayment Programs. LRPs are not research grants per se; they were designed to provide relief from student loans for translational and clinical investigators in their late postdoctoral or early faculty years and reflect a first attempt at NIH funding



Percentage of female applicants and success rates. (Top) Summary of pooled data from 2003 to 2007 showing the percentage of female applicants for six different NIH grant types. (Bottom) Success rates for females (red) and males (purple). * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$. R01-1 refers to first-time R01 applicants, and R01-E to experienced R01-equivalent investigators.

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for most applicants (15). On average, applicants were in their mid- to late 30s.

Mentored Early Career Awards (K08, K01, and K23). Many LRP holders will apply for K series awards. K08 awards are predominantly applied for by M.D.'s and M.D./Ph.D.'s, and generally address basic or translational scientific questions. K01 awards are more basic in scientific scope, and nearly all applicants are Ph.D.'s. K23 awards are designed to support translational and clinical research, and most applicants are M.D.'s and M.D./Ph.D.'s. On average, applicants for these awards were in their late 30s.

Investigator-Initiated Research Project Grants (R01s). A large fraction of K award holders will apply for R series awards. We evaluated the number of first-time applicants for R01 awards (i.e., applicants who had never before received a competitive major research grant from the NIH), and also evaluated experienced R01-equivalent investigators (16) (i.e., who had been funded via a competitive major research grant). On average, applicants for first-time awards were in their early to mid-40s, and experienced investigators were in their early to mid-50s.

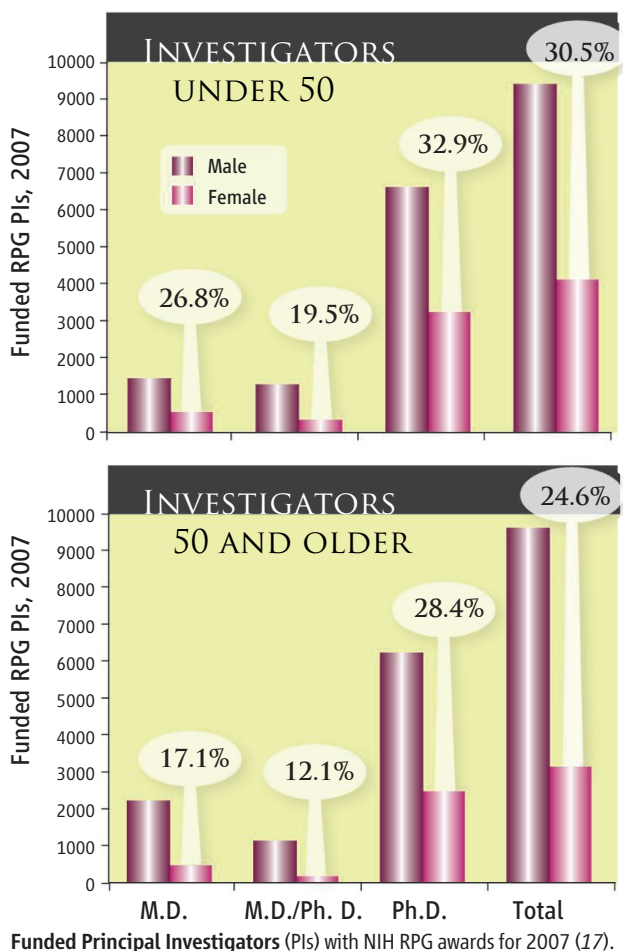
Loss of Female Applicants as Careers Progress

Applicant and award data from the past 5 years (2003–2007) are presented in supplemental online material (figs. S1 to S6 and tables S1 to S6). The data were pooled to smooth minor year-to-year variations, and are summarized here (see chart, bottom of page 1472). Statistical evaluations of this data set are presented in table S7. The trends for the past 5 years have generally been consistent, and the most current data from 2007 is very similar to that of the pooled data.

For M.D.'s, numbers of male and female applicants for LRPs and K23s have been virtually equivalent for the past 5 years (see top of chart, page 1472), mirroring the nearly equal numbers of male and female medical students. However, the number of female M.D.'s applying for K08 awards was strikingly reduced compared with males (535 versus 1077, $P <$

0.001); this trend continues for first-time R01 applicants (1596 females versus 3541 males, $P <$ 0.001; change from K08, $P = 0.1101$) and is significantly lower for experienced R01 applicants (2133 versus 9620, $P <$ 0.001; change from first-time R01, $P <$ 0.001).

The same general patterns are evident for female M.D./Ph.D. grant applicants (see top middle of chart, page 1472), but this cohort is significantly underrepresented from the beginning of the pipeline, probably because gender parity has not yet been reached in M.D./Ph.D. programs (171 of 500 graduates in 2008 were female).



Female M.D./Ph.D. applicants were significantly underrepresented in the LRP pool (129 versus 368), the K08 pool (240 versus 763), the K01 pool (67 versus 91), and the K23 pool (108 versus 162; $P <$ 0.001 for the differences between male and female applicants for all four grant types). This trend continues for first-time R01 applicants (903 females versus 3475 males, $P <$ 0.001; change from K08, $P = 0.0211$) and worsens for experienced R01 applicants (1244 female versus 6741 males, $P <$ 0.001; change from first-time R01, $P <$ 0.001).

For Ph.D.'s, the same trends are evident (see top right of chart, page 1472), but the most dramatic decline in applicants occurred at the first R01 application. For LRPs, female applicants substantially outnumbered males from 2003 to 2007 (2345 versus 1307, $P <$ 0.001). Likewise, for K23s and K01s, female applicants have significantly outnumbered males (K23, 461 versus 239, $P <$ 0.001; K01, 1274 versus 1175, $P = 0.0023$). However, for first-time R01 applicants, only 9144 of 26,836 total applicants were female between 2003 and 2007 ($P <$ 0.001; change from K01, $P <$ 0.001); for experienced R01 applicants, the trend worsens (13,460 versus 35,427, $P <$ 0.001; change from first-time R01, $P <$ 0.001).

Near-Equivalent NIH Funding Success Rates for Women

Despite the oft-held perception that women do not fare as well in the NIH grantee pool as men, the data show that funding success rates for nearly all grants were essentially equal for men and women, regardless of degree (see bottom of chart, page 1472). For M.D.'s, the only significant differences in success rates for men and women were for R01 applicants: First-time women applicants had a 20% success rate, compared with 24% for men ($P = 0.006$); 32% of experienced female applicants were successful, compared with 36% of men ($P = 0.0004$). Female and male M.D./Ph.D.'s were equally successful at obtaining grants at all stages of the career path, except for K01 awards (with only 158 total applicants over 5 years, 91 males and 67 females), and experienced R01 applicants, where the difference between success rates for females (31%) and males (34%) was statistically significant ($P = 0.012$). Finally, success rates were the same for male and female Ph.D. investigators at all stages of the career path, except for experienced R01 investigators, where women had a 33% success rate, compared with men at 35% ($P <$ 0.0001). When the data are pooled for all investigators and all grants studied here from 2003 to 2007, the success rates for men and women are virtually equivalent (31% success for women, and 32% for men).

To examine the consequences of these application and success rates on the current pool of funded NIH investigators, we obtained information from the NIH regarding all Principal Investigators for Research Project Grants (RPGs) (17) (see table S8 and chart, left). Women were significantly underrepresented ($P <$ 0.001 for all categories). This trend is more severe for women over the age of 50, and is most severe for physician-scientists in both age groups.

Conclusions

Our data show that career paths for men and women in the biomedical sciences are different and that degree type influences career outcome. For the past several years, the numbers of female and male Ph.D. and M.D. students have been nearly equal, whereas female M.D./Ph.D. students compose about 40% of the total pool. Well into the postdoctoral years (through LRP grant applications), women and men are at least equally represented in the career path. Although female physician-scientists applying for mentored translational grants (K23 applicants) are equal in numbers to men, we estimate that nearly half of the women eligible to pursue more basic research themes (K08 applicants) are not applying. For Ph.D.'s, this trend is also clearly evident at the transition from LRP to K01, but the loss is most dramatic for first-time R01 applicants.

Although some female career attrition could be due to cohort effects (i.e., smaller numbers of female graduate students in the past, leading to smaller numbers at advanced career stages at this time) the effects that we describe here occur in a very narrow time frame and are far too large to be totally explained by this phenomenon. Instead, the data strongly suggest that a large fraction of women are choosing to leave the NIH-funded career pipeline at the transition to independence (i.e., in the late postdoctoral and early fac-

ulty years). Female physician-scientists make this decision earlier and more often, perhaps because more attractive and/or flexible career options (e.g., clinical practice) are available to them. Men and women have near-equal NIH funding success at all stages of their careers, which makes it very unlikely that female attrition is due to negative selection from NIH grant-funding decisions.

Women make up an ever-increasing fraction of the students who train to become biomedical scientists, but their career attrition is disproportionate to that of men. If these trends continue, this country will probably experience a shortage of biomedical scientists in the near future. We therefore hope that these data will provide an impetus for the NIH and academic leaders to develop more effective strategies to retain women at the critical juncture between postdoctoral training and independent careers. The attrition of women from this career path represents a critical loss of intellectual capital for all of biomedical research. Women are equally prepared for careers in the biomedical sciences, and they are successful at obtaining NIH grants at all career stages; their potential for great contributions to biomedical science cannot be wasted.

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17. R01 equivalents include R01, R23, R29, and R37 grants.
18. RPG grants include: R00, 01, 03, 15, 21, 22, 23, 29, 33, 34, 35, 36, 37, 55, 56, P01, P42, PN1, UC1, UC7, U01, U19, DP1, and DP2 awards.
19. The authors thank I. Lederhendler, R. Moore, E. Stalder, Z. Liu, S. Boehler, P. Reed, G. Garrison, J. Youngclaus, H. Alexander, C. Mikesell, and F. Slapar for providing key pieces of data. We also thank L. Rosenberg and S. Kornfeld for helpful discussions. The Alan A. and Edith L. Wolff Professorship (T.J.L.) and the Robert Brookings Smith Professorship (B.H.H.) provided support.

Supporting Online Material

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POLICY

Science Policy in Kazakhstan

Glenn E. Schweitzer

In 2006, Kazakhstan President Nursultan Nazarbayev proclaimed that Kazakhstan would advance from the world's 56th most economically competitive nation to the ranks of the top 50 within a decade (1, 2). Science and technology were to be the driving force. But now, this arid country the size of Western Europe with a population of only 15.2 million has fallen to 66th (3).

In 2006, the president announced that the nation's investment in scientific research would increase 25 times within 6 years (4), measured in the local currency, the tenge. Taking into account trends in inflation and currency exchange rates, reaching this goal

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would probably result in an astounding 5- to 10-fold increase in purchasing power (5). In reality, research investment has stayed level, slipping from 0.2 to 0.15% of Gross Domestic Product (GDP), as national income from oil exports expands.

Buoyed by dramatic increases in oil revenues and abundant supplies of exportable gas, uranium and other minerals, and grains, as well as oil, the president's vision was undoubtedly sincere. He recognizes the importance of diversifying the economy beyond exports of natural resources. But there are obstacles. At the top of the list is a government bureaucracy that has not bought into the president's vision. "The president has other priorities as well" is the favorite bureaucratic rejoinder to science and technology advocates.

A robust science and technology infrastructure is an essential ingredient for devel-

Although the president of Kazakhstan advocates improving science and technology infrastructure, little has been done.

opment of middle-income economies. But even with substantial financial resources, harnessing the power of science and technology is an elusive long-term challenge, and technical wherewithal is only one element of economic progress. Only with effective fiscal, trade, industrial, natural resource, agricultural, environmental, health, and social policies will science and technology have an opportunity to achieve the much-heralded status of an engine of economic growth in Kazakhstan or other countries.

The Critical Role of Human Resources

In parallel with development of a more favorable policy environment must be an unprecedented effort to develop a much stronger human resource base. Managers, researchers, practitioners with technical skills, technicians in many fields, and science and technology