Analysis of the workforce and workplace for rheumatology, and the research activities of rheumatologists early in their careers

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Objective. Assess the workforce and workplace for rheumatology, and the investigative work of early career rheumatologists.

Methods. Early career rheumatologists were defined as practicing physicians that joined the American College of Rheumatology (ACR) in 1991-2005, were 49 years of age or younger on joining, and resided in North America. This cohort participated in a Web-based survey distributed by ACR. A total of 247 survey instruments (21.2 % response) were used for this analysis. Survey questions were designed to obtain core insights about: the workforce, workplace, investigative activities, funding, and demographic profile.

Results. Respondents from all workplaces---clinical, academic, federal, industrial---engaged in clinical care, teaching, administration, and research. The time devoted to these tasks was employer dependent, and workplaces shaped the scale and scope of research. Patient-oriented research was predominant across all workplaces. Disease-, population-, and translational-

research was intermediate, and few respondents pursued basic- or prevention-oriented research in any workplace. Rheumatologists obtained extramural (21.3 %) and intramural (78.7 %) funds to pay portions of their salaries for time spent on research. Receiving an NIH K08/K23 award was associated with receiving federal research-project grants ($P < 0.001$). Respondents associated investigative work with reduced earnings, a perception validated by an estimated drop in pre-tax annual earnings of 2.3% for each half-day/wk dedicated to research ($P < 0.01$).

Conclusions. The results justify interventions for closing gaps embedded in investigational rheumatology. These include: improved funding for clinical research, increasing the number of K08/K23 awards; and recruiting rheumatologists from underrepresented demographic groups.

Clinical research commands a pivotal position in the overall structure of medicine for several reasons. First, and foremost, clinical investigation is the proving ground for all innovations and discoveries that advance the practice of medicine. Second, clinical research serves as the training

ground for producing the next generation of investigators needed to sustain medical progress. Third, a reward structure has evolved among clinical investigators leading to peer recognition, and the opportunity to obtain funds required for the production of a public good. In the case of rheumatologists, clinical investigation serves as the mechanism to advance clinical practice through the development of improved diagnostics, new treatments, and preventions that enhance the lives of the thousands of patients that suffer from a disorder occasioned by persistent pain and accumulated disability (1).

The scope and scale of clinical research is unknown for any medical or surgical specialty beyond snapshots of the broad aims and expenditures of research programs sponsored by federal agencies or the pharmaceutical industry (2-4). As a consequence, the workforce and workplace for clinical investigation is enigmatic and unexamined even after explicit warnings that an essential arm for advancing clinical practice has been disabled (5-8). The present study was designed to assess the workforce and workplace for rheumatology, and the extent and type of research prevailing among rheumatologists early in their careers. Our findings provide fresh insights about the workforce and the workplace for rheumatology, and justify interventions to address gaps in both the scope and scale of clinical research in arthritis and rheumatism.

MATERIALS AND METHODS

Survey participants. The ACR is the primary professional organization dedicated to advancing the practice of rheumatology in North America. An agreement was made with the ACR to distribute a Web-based questionnaire, produced by the authors, to member's email addresses. A letter of invitation from the ACR preceded respondent access to the survey instrument.

Rheumatologists, early in their careers, were identified based on five criteria: joined ACR between January 1, 1991 and December 31, 2005, earned an MD or equivalent degree, held an active license to practice medicine, resided in Canada or the US, and were 49 yr of age or younger on joining ACR. These criteria were adopted to assess physicians that complete fellowship training at a mean age of 34 yr, obtain support for their first research project grant at a mean age of 44.2 yr if they compete for federal grants/contracts, and function as principal investigator (PI) or co-principal investigator (Co-PI) for at least 5 yr (9).

Prospective respondents received an original email, and two follow-up email reminders if they failed to return a survey questionnaire between December 2007 and February 2008. The survey tool is available at <http://www.cornellsurveyresearch.com/sri/files/Rheumatology_Que

stionnaire.pdf>. A total of 265 rheumatologists responded to this study. Incomplete surveys were discarded making 247 questionnaires available for analysis, yielding a final response of 21.2 %. The survey protocol adopted for this study was consistent with that used by the ACR to survey members about services or issues affecting the practice of rheumatology. The mean response for three ACR surveys performed in 2007-2008 was 25.7 % (10), a value approximating the response rate achieved here.

Participant instructions noted that the Board of Directors of ACR approved the survey, and that IRB approval was obtained, for an exempt protocol, from the Office for the Protection of Research Subjects, University of Illinois at Chicago, Chicago, IL. Respondents were advised that participation was voluntary, confidentiality would be maintained, and that none of the research conducted or published would divulge the responses of individual physicians. Questionnaires were submitted anonymously over the Internet. Survey security was maintained by using secure servers to direct participant responses over the Internet and store data.

Design of survey instrument. A preliminary version of the survey questionnaire was tested for ambiguity and errors. A random sample of 50 rheumatologists, satisfying all early career criteria, was asked to respond to a prototype questionnaire.

Pilot survey participants were instructed to provide written comments on any question that was ambiguous, awkward, or impertinent. A total of 18 participants returned questionnaires used to reformat the survey. The responses of pilot survey participants were excluded from this report.

The final version of the survey questionnaire asked participants to identify their employment sector, designate the half-days/wk spent on administration, clinical care, teaching, and research, specify the source(s) of salary support for time spent on research, and indicate their annual pre-tax compensation within ordered ranges. Respondents were asked to specify one or more types of research that typified their investigative activities over the past 12 months. Clinical research was defined to be inclusive, embrace the recommendations of a consensus development conference convened to codify clinical investigation, and respect definitions adopted by others (6, 11,12).

A series of positive and negative questions were used to examine the basis for incentives and disincentives for pursuing investigative careers. Questions relied on a 4-point Likert scale (13) that was collapsed to consider two outcomes: agree or disagree. A second set of questions considered institutional support for research during residency and fellowship training, extramural funding for post-fellowship training in research, and

the receipt of extra- and/or intra-mural funds for research projects as a PI or Co-PI. The last question set considered respondent age, citizenship (Canada or US), gender, and ethnic background. The ethnic background of individuals graduating from allopathic schools of medicine in the US was estimated by calculating the mean distribution of ethnic groups graduating in 1991-2005 (14).

Data analysis. A unique, computer generated, case number was assigned to each questionnaire to respect respondent confidentiality throughout this study. Statistical assessments were made with software produced by Stata (version 6.0, Stata, College Station, TX). Pearson's chi-square goodness-of-fit-test was used to determine whether the cohort of survey respondents differed from the population of prospective participants. Results involving multiple comparisons among groups relied on testing whether distributions differed across groups or in the case of means whether the means differed between or among groups. Data involving frequency statistics, such as yes/no responses and the distribution of women/men, were compared via Pearson's chi-square goodness-of-fit-test. Statistical assessments involving means relied on the analysis of variance, or a simple paired T-test for between group comparisons.

A multiple regression model was used to test the association between the receipt of grants by PI's and Co-PI's.

Probability estimates of regression coefficients assumed that tested variables were distributed randomly. Assumptions underling the unmodified ordinary least squares model included: linearity, full rank, exogeneity of independent variables, homoscedasticity of error terms, and exogenously generated data. Results are reported as two-sided P-values.

A Tobit regression model was used to determine the association between pre-tax annual earnings and various outcome measures to accommodate the censored earnings that respondents reported within specified ranges. We tested dependent variables, with binary responses, using the logit regression model with the assumption that the natural log of the probability ratio is approximated by a linear function. Certain respondents failed to report the number of half-days spent on research, or provide information related to the submission of proposals for research project grants. The absence of a response, in a few cases, is assumed to be zero or identical to the no-responses entered by most respondents. This transformation was based on the assumption that rheumatologists who are uninvolved in research would likely overlook the need to document a zero response.

RESULTS

Respondent sample. The cohort of prospective participants was compared with the respondent sample to test whether or not the two populations differed on the basis of gender mix, age

distribution, location of states within the US, and country of residence. The tested criteria were similar in both populations (P > 0.20), an indication that the 247 survey participants were representative of ACR members early in their careers.

Respondent profile. A respective 10.5 % and 19.9 % of respondents earned baccalaureate and MD (or equivalent) degrees outside of North America. Residency and fellowship training was accomplished in North America by 98.6% of respondents.

Respondents completed medical school at 27.1 ± 0.2 years of age (mean ± SEM) and finished fellowship training at 33.7 ± 0.2 years of age (mean ± SEM), an elapsed interval of 6.6 ± 0.2 years (mean ± SEM). Women and men completed pre-and post-clinical training at similar ages (P > 0.25). Over 99% of the respondents reported they were board-certified or board-eligible in either adult or pediatric rheumatology, an indication that respondent training was consistent across these two related subspecialties.

Most respondents resided in the US (95 %) and the remainder in Canada (5 %). The mean fraction of citizens, permanent residents, and non-citizens from the US was 85.8 %, 8.5 %, and 5.7 %, respectively. The fraction of citizens, permanent residents, and non-citizens among
Canadian rheumatologists were similar to those of rheumatologists from the US (P > 0.50). The gender mix of early

career participants from the US was 44.8 % women and 55.2 % men. Respondent data, from both countries, were merged into a single data set since no significant differences ($P > 0.50$) were evident in any demographic measure (age, gender, ethnic background).

The self-identified ethnic backgrounds of rheumatologists from the US were compared with graduates of allopathic schools of medicine (Table 1). The distribution of respondents from Asian and Hispanic/Latino backgrounds approached that of US graduates (Table 1). The number of Black or African American rheumatologists, in contrast, was underrepresented in this survey sample by 6.5% while the number of Caucasians was overrepresented by a similar amount when compared with the cohort of individuals earning an MD degree in 1991 to 2005 (Table 1).

Workplace assessment. The time devoted to clinical service, teaching, research, and administration was estimated by asking respondents to specify the half-days/wk committed to these activities (Table 2). Clinical care was accomplished across all workplaces. Respondents employed in a solo or group practice, or health system, spent 7.9 half-days/wk on clinical service, a commitment exceeding that of other workplaces ($P < 0.05$). In contrast to providers, respondents employed by academic medical centers/teaching hospitals (AMCs), federal government, and

pharmaceutical/biotech industry worked a respective 3.5, 2.3 and 1.5 half-days/wk on clinical service (Table 2).

Rheumatologists from all workplaces participated in teaching medical students, residents, or fellows (Table 2). Academic respondents devoted 1.3 half-days/wk to teaching whereas providers, federal employees, and those from industry spent 0.4, 0.6 and 0.5 half days/wk, respectively, which was significantly less ($P < 0.01$) than academics (Table 2). Clinical care providers spent 1.4 half-days/wk conducting research. Respondents from AMC's reported dedicating 4.0 half days/wk to research, while those in the federal and pharmaceutical/biotech sectors spent a respective 4.8 and 5.1 half days/wk (Table 2). Administrative work, including committee responsibilities, involved 0.8 half days/wk among providers, 1.5 half days/wk in academic and federal workplaces, and 3.8 half days/wk in industry (Table 2).

Scope and scale of research. The extent and type of research pursued by respondents was workplace dependent (Table 3). No gender disparities were evident, in any workplace, among the fraction of respondents involved or uninvolved in research or in the distribution of respondents pursuing basic and clinical research ($P > 0.25$).

In the clinical care workplace, 59.3 % of providers pursued research albeit at levels below workplaces providing dedicated

research time (Table 3). Patient-, disease-, and population-oriented research involved a respective 36.4 %, 9.3 % and 6.8 % of providers. Providers pursued basic-, translational-, and prevention-oriented research, but the fraction of respondents was limited to 1.9 % to 3.1 % (Table 3).

The extent and type of research accomplished in federal and pharmaceutical workplaces was similar ($P > 0.15$). Academic respondents devoted analogous attention to patient-, disease-, and population-oriented research ($P > 0.25$) as indicated by respective commitments of 21.6 %, 19.5 %, and 19.5 %. Basic-, and translation-oriented research involved respective efforts of 13.7 % and 11.6 %, while prevention research was limited to 4.2 % (Table 3).

Analysis of the extra- and intra-mural funds used by respondents to defray a portion of their salaries for time spent of on research indicated no gender disparities ($P > 0.25$) were evident in extra- and intra-mural support available to women and men. Grants/contracts, from federal and nonfederal sources, supported the salaries of 21.3 % of respondents. The remaining 78.7 % of respondents relied on intramural funding to pay for research time. Intramural funds were derived from: clinical earnings (39.7 %), medical schools and/or hospitals (14.5 %), endowments/other sources (8.3 %), and the salaried commitments of federal (8.3 %) or pharmaceutical (7.9 %) employers.

The proposals submitted and grants/contracts received by early career rheumatologists from the US indicated that 20.6 % of respondents applied for post-fellowship research training from federal and non-federal sources, and 13.1 % submitted applications for NIH K08/23 awards (Table 4). An average of 1.8 proposals was required per K08/23 award with a success rate of 41.1% per respondent or 22.2 % per application (Table 4). Fewer training proposals were submitted to the VA in comparison to NIH, but with comparable success rates (Table 4). The receipt of an NIH K08/23 award was a consequential marker of research project grants awarded to PI's and Co-PI's ($P < 0.001$). Specifically, rheumatologists receiving a K-award were estimated to receive an average of 2.8 and 1.2 federal research project grants as respective PI's or Co-PI's. The association between the receipt of K-award and the subsequent receipt of a research project grant was independent of gender ($P < 0.01$). Women and men recipients of K-awards were just as likely to receive NIH R01 awards.

Respondents, from the US, produced 319 proposals as PI's or Co-PI's (Table 4). Prospective PI's submitted an average of 2.8 research project proposals to NIH, and received 2.0 awards for a success rate of 51.1 % per respondent or 31.1% per proposal (Table 4). Fewer proposals were submitted to non-NIH HHS agencies and the VA, but respondent success exceeded ($P < 0.05$)

that for NIH awards (Table 4). The success of investigator-initiated proposals considered by philanthropy, industry, and other funding sources was a respective 42 %, 43%, and 50% (Table 4). Proposals submitted by Co-PI's were funded on the same order ($P > 0.15$) as those of PI's (Table 4).

Individual and institutional commitments to research. Respondents were queried about their interest in pursuing investigative careers as medical students, residents, and fellows. The fraction of positive responses (yes) increased from 28.7 % for medical students, 38.6 % for residents, and 60.3 % for fellows. The same cohort was asked to indicate whether they were aware of opportunities to participate in faculty-mentored research projects. Only 22.7 % of medical students and 25.5 % of residents reported being aware of such opportunities, whereas 67.6 % fellows acknowledged the possibility of participating in faculty-sponsored research. Potential deterrents to pursuing a research career were examined to identify interventions that can enhance the workforce for investigative rheumatology. The time and energy required for a meaningful research career was not considered to be more demanding than that required for a similar career involving clinical service ($P > 0.25$).

Rheumatologists (72.4 %) viewed job uncertainty as a significant concern for clinical investigators relative to providers ($P < 0.01$). Respondents (75.6 %) perceived that the

earnings of clinical investigators were less than those of providers ($P < 0.01$). This perception was tested by using a Tobit regression model specifying the natural logarithm of pre-tax annual earnings as a function of two key explanatory variables – years post fellowship and half-days/week devoted to research – as well as variables to control for gender, employment sector, and total work hours per week. The results indicate that pre-tax annual earnings increased linearly at 1.8 % per year of post-fellowship experience (Fig. 1A). However, the earnings of rheumatologists devoting two or more half-days/wk to investigative work fell by 2.3 % per year for each half-day/wk spent on research ($P < 0.01$) relative to individuals spending one half-day/wk or less on investigative work (Fig.1B).

Institutional support for early career academics was estimated by using the total dollar value of start-up packages provided for personnel, equipment, supplies, and other research expenses. Investment in the research programs of early career academic rheumatologists increased linearly with the number of half-days/wk devoted to research (Fig. 1C).

DISCUSSION

The present study provides important new insights about the workforce and workplace for rheumatology, and extends knowledge about the extent and type of research accomplished by rheumatologists early in their careers. The findings rely on

self-reported responses to a Web-based questionnaire to assess the administrative, clinical, didactic, and investigative work of rheumatologists affiliated with academic, clinical, federal, and industrial employers. The results fill a gap occasioned by the lack of a national protocol for appraising clinical investigation and its practitioners. Our report establishes a template for estimating the scope and scale of clinical research within medical subspecialties, and the assessment of explanatory variables---categorical and continuous---that inform policy and furnish a rational framework for interventions enhancing innovation and discovery in investigative rheumatology.

The analysis of administrative, clinical, didactic, and investigative work established that the time devoted to these tasks is workplace dependent (Table 2). The novel aspect of this assessment involves the dissection of workplaces based on the extent and type of research pursued by early career rheumatologists. Research, of all types---basic-, translational-, disease-, patient-, population-, prevention---was accomplished by academic, federal, industrial, and provider workforces. However, the results show that the scope and scale of research is a hallmark of the workplace (Table 3). The provider workplace, for example, emphasized patient-oriented studies, a focus exceeding all other research endeavors by four- to five-fold. Providers may direct or participate in various clinical

protocols, including registries, cohort studies, and multicenter clinical trials of new drugs (Table 3). While the survey did not distinguish among these possibilities, it seems likely that most provider research involved patient enrollment in protocols developed and funded by industrial or federal sponsors since provider research time was restricted to 15.3 % of their total professional effort (Table 2). Certain rheumatologists in private practice, however, are known to participate in registries and other prospective cohort studies.

Rheumatologists employed in federal and pharmaceutical workplaces devoted more time to research than any other activity, and the distribution of investigative approaches was similar in both workplaces (Table 3). The minor distinction between the two workplaces pivoted on translational research in the pharmaceutical industry, an investigative emphasis exceeding that of all other workplaces. Research in the academic workplace was dispersed among multiple investigative activities. The diversity of investigative pursuits within the academic workplace contrasts with the focal specificity of research in other workplaces.

Prevention-oriented research, however, emerged as an orphan enterprise across all workplaces considered here. Stakeholders should consider this void as a singular opportunity to plan interventions aimed at promoting prevention research among early

career rheumatologists. Such research would provide a platform to establish an individual's risk for developing disease, provide protocols to prevent disease onset, and make it possible to intervene at the earliest possible time when disease occurs (15-17). Adoption of such a paradigm would begin the transformation of rheumatology from a curative to a preventative focus with personal health care planning (15).

Analysis of the proposals produced by respondents for research grants/contracts provided new information about rheumatologists receiving K08/23 awards. We observed a compelling association ($P < 0.001$) between recipients of K08/23 awards and the subsequent award of an estimated 2.8 NIH research project grants. While the survey questionnaire did not control for all possible variables needed to predict the success of K-awardees as future recipients of federal research grants, the unequivocal effectiveness of K-awardees, observed here, provides the logic for proposing a modest increase in the number of K08/23 awardees to support approximately 8 % of the 240 individuals that complete fellowship training in adult or pediatric rheumatology each year (18).

The present assessment of the academic workforce indicates that investigative rheumatology is hobbled at multiple levels. First, investigative work is highly leveraged on intramural funds as opposed to extramural grants/contracts. This assertion

stems from finding that almost 80 % of academic rheumatologists relied on intramural funds to cover a portion of their salary for time spent on research. Clinical earnings were used to generate about 40 % of the intramural funds used by early career academics or almost twice the support derived from extramural grants/contracts. Next, the time available for research was limited by the need to accomplish service-related tasks among early career academics. Finally, less that 6 % of academics received an NIH K08/23 award for post-fellowship research training (Table 4). Beyond this set of workforce constraints resides a host of limitations tied to an ailing and outmoded national infrastructure for sustaining clinical research (11, 19). For instance, a disparity approaching 2:1 prevails for funding basic versus clinical research by federal agencies (20-21), and a recent report documents the difficulty of funding clinical research and population-based studies by individual institutes within NIH (22). The summed constraints in both the workforce and federal-institutional partnership prompts the suggestion that stakeholders in rheumatology---academic, federal, industrial, philanthropic, professional---pursue interventions for the gradual systematic growth of clinical research in rheumatology. The intent of this proposal is to enlarge the fraction of rheumatologists with research training (K-awardees) so they can subsequently gain extramural research

support for research project grants, and have the time and funding to advance the clinical practice in rheumatology.

Consideration of the deterrents for pursuing investigative careers indicated that 75.6 % of respondents perceived that providers held an earnings advantage over clinical investigators. This perception was verified by showing that pre-tax annual earnings fell by 2.3 % for each half-day/wk devoted to investigative work among rheumatologists spending 2 or more half-days/wk on research (Fig 1B). The observed disparity in annual earnings does not reflect the presumed remuneration to mid-career and established researchers that went undetected because this study focused on early career investigators. Clinical investigation, moreover, remains the source of non-monetary rewards, including: peer recognition for innovation and discovery, the opportunity to obtain extramural funds for the production of a public good, and the self-satisfaction of championing advances in clinical practice. The significance of a "research cohort" to rheumatology far outweighs their number in the clinical workforce since a single innovation offers the potential to benefit thousands of patients by transforming the clinical management of a particular condition (23).

The assessment of self-identified ethnic backgrounds identified a gap in the fraction of Black or African American respondents within the workforce for rheumatology (Table 1). The

under representation of rheumatologists, from any demographic background, is of intrinsic importance to investigative rheumatology because the ethnic profile of volunteers agreeing to participate in a clinical trial reflects the ethnic background of physicians directing the study (24). Reliable estimates of the safety/efficacy of new drugs or treatments are unachievable unless the participants in a clinical study approximate the demographic profile of the US population (25-26). Disparities in the ethnic backgrounds of practicing physicians point to the need to pursue interventions designed to recruit future generations of rheumatologists that mirror the demographic norms of graduates from allopathic schools of medicine in the US (14, 27-29).

The present study is based on a limited number of survey participants. Responder participation in this survey, however, was consistent with that of other surveys accomplished by the ACR. Further, statistical comparisons of responders and non-responders established that both cohorts were similar ($P > 0.25$) based on gender mix, age distribution, residency within states in the US, and country. Finally, the demographic profile of survey respondents conforms to data reported in the annual survey of graduate medical education for rheumatologists (18), and data on the workforce for rheumatology (30). Despite this evidence, the results should be viewed as an indicator rather

than absolute measure of the workforce, workplace and the research accomplished by early career rheumatologists.

In conclusion, this study calls attention to multiple issues limiting advances in investigative rheumatology. The findings provide stakeholders---academic, federal, industrial, philanthropic, professional---with an evidence-based rationale to pursue multiple interventions for remodeling clinical research in rheumatology. The present results are not intended to detract from recent initiatives, championed by NIH, to improve the climate for clinical scholarship (31-33). Instead, the findings compliment and extend the efforts made by NIH, and provide a rational framework to initiate a national dialog aimed at establishing a public and private infrastructure to support investigative rheumatology prudently and amply (34). Only then will a bright future be assured for innovation and discovery in rheumatology, and benefit patients debilitated by musculoskeletal diseases.

AUTHORS CONTRIBUTIONS

C. Desjardins had access to all of the data in this study, and assumes responsibility for the integrity of the data and the accuracy of the data analysis.

Study design. Desjardins and St. Clair.

Acquisition of data. Desjardins and Survey Research Institute, Cornell University, Ithaca, NY.

Analysis and interpretation of data. Desjardins, Ehrenberg, St. Clair.

Manuscript preparation. Desjardins, Ehrenberg, St. Clair.

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Table 1. Self-identified ethnic backgrounds of rheumatologists, early in their careers, and graduates of allopathic schools of medicine in the United States.

Ethnic background	Self-identified backgrounds (mean %)*			Graduates of US medical schools (%)†
	Women	Men	Both genders	
American Indian or Alaskan Native‡	---	---	---	0.7
Asian American	16.8	14.4	15.5	16.9
Black or African American	0.9	0.0	0.4	6.5
Caucasian	72.9	76.5	74.9	68.7
Hispanic or Latino American	5.6	6.1	5.9	6.4
Multiethnic	1.9	0.8	1.3	Unreported
Other: unknown or unreported§	1.9	2.3	2.1	0.8

*Each value is expressed as the mean percent of responses reported by early career rheumatologists that consisted of 107 (44.8 %) women and 132 (55.2 %) men out of a total of 239 eligible graduates of allopathic medical schools in the US.

† The ethnic backgrounds of allopathic medical school graduates in the US was determined by estimating the mean number of individuals, within specified ethnic groups, that graduated from allopathic schools of medicine, each year, and from1991 to 2005 (14). An average of 15,713 physicians graduated per year between 1991 and 2005, the same 15-year sample window adopted for the present survey of rheumatologists early in their careers.

‡ The number of American Indians and Alaskan Natives was not determined in this study, but are listed here to coincide with the demographic profiles of graduates from allopathic schools of medicine in the US (14).

§ The fraction of individuals that self identified as "other" may include rheumatologists from ethnicities (American Indian, Alaskan Native, Hawaiian Native, Pacific Islander) that were unlisted in the survey instrument for this study, or it may consist of individuals whose ethnicity is unknown or undisclosed.

Table 2. Time committed to clinical service, teaching, research, and administration among workplaces employing early career rheumatologists.

Activity	Time commitments in half-days/wk (mean ± SEM)* (percent effort)			
	Clinical care providers†	AMC teaching hospital‡	Federal§ HHS/DOD/VA	Pharmaceutical biotech/industry
Clinical service	7.9 ± 0.2 (74.7)	3.5 ± 0.2 (34.9)	2.3 ± 0.4 (21.6)	1.5 ± 1.3 (13.6)
Teaching¶	0.4 ± 0.1 (3.6)	1.3 ± 0.1 (11.9)	0.6 ± 0.2 (6.8)	0.5 ± 0.4 (4.5)
Research	1.4 ± 0.1 (15.3)	4.1± 0.3 (38.7)	4.8 ± 0.9 (52.8)	5.1±0.9 (44.1)
Administration∫	0.8 ± 0.1 (6.4)	1.5 ± 0.1 (14.5)	1.5 ± 0.3 (18.8)	3.8 ± 1.5 (37.8)
Totals	10.5 ± 0.1	10.4 ± 0.2	9.2 ± 0.3	10.9 ± 0.7

* Each value is expressed as the mean ± standard error of half-days/wk reported by respondents for each of the designated activities. The numbers in parenthesis are expressed as the mean percent effort within each workplace to facilitate comparisons among workplaces. The results are based on 226 early career rheumatologists out of a total of 247 eligible respondents. The number of respondents employed in clinical care, AMC's, federal government and industry was 113, 96, 10 and 7, respectively. Note some respondents did not qualify for inclusion in this data set because they were unaffiliated with one of the four employers designated here.

Respondents were asked to specify the half days/wk devoted to the indicated activities during the 12 mo the preceded the survey based on the time they negotiated with their supervisors. The results provide an estimate of the time/effort reported for a putative 40 hr workweek since respondents were advised to exclude "off-the-clock" commitments for activities accomplished

after normal working hours or on weekends, holidays or vacation periods. Note that the "total" half-days/wk deviate from the expected value of 10. Values were not normalized to 40 hr/wk to allow the data to reflect the actual time reported by respondents within each workplace.

†Clinical care providers refer to early career rheumatologists who deliver clinical care as an owner/partner of a solo or group practice, or are employed by a group practice, health system, or hospital.

‡AMC: academic medical center refers to any medical school or teaching hospital accredited to sponsor a residency program in internal medicine or pediatrics, or a fellowship program in adult or pediatric rheumatology or both as approved by the Accreditation Council for Graduate Medical Education <http://www.acgme.org>.

§Federal government: includes any early career rheumatologist employed by the Department of Health and Human Services (HHS), Department of Defense (DOD), or the Department of Veterans Affairs (VA).

¶Includes the total time devoted to all teaching: medical students, residents, or fellows.

∫Includes the total time devoted to both administrative work and committee assignments.

Table 3. The effect of workplace on the type of investigative work accomplished by rheumatologists early in their careers.

Type of investigative activity	Workplace and/or employer (%)*			
	Clinical care provider†	Federal government‡ HHS/DOD/VA	Pharmaceutical or biotech industry	Academic medical center§
None	30.9	4.8	6.3	5.5
Basic	2.2	9.5	12.5	14.4
Translational	2.2	9.5	18.8	12.2
Disease-oriented	10.8	23.8	18.8	20.4
Patient-oriented	42.4	42.9	37.5	22.7
Population-oriented	7.9	9.5	6.3	20.4
Prevention-oriented	3.6	0	0	4.4

* Each value is expressed as the mean percent of early career rheumatologists reporting a commitment to one or more of the investigative activities within designated workplaces. The results are based on 244 early career rheumatologists out of 247 eligible respondents. Note, respondents were allowed to specify one or more of the designated activities to reflect the type of investigative work pursued in the 12 mo preceding the survey. Investigative activities were defined using terminology adopted by others (6, 11-12), and appeared as follows in the survey tool: *Basic research*: laboratory-based research involving the development of new drugs, technologies, or devices. *Translational research*: bench to bedside or bi-directional research involving human subjects known to the investigator, excluding the use of human specimens (cells/tissues) for laboratory studies.

Disease-oriented research: requires use of human subjects to investigate the mechanisms or natural history of disease, or improve the detection or diagnosis of disease. *Patient-oriented research*: clinical trials, including Phase I, II, III, IV trials of drugs, biologics, devices, and the evaluation of therapeutic interventions. *Population-oriented research*: outcomes studies of populations, health services and cost effectiveness research, studies of health quality including best practices and medical errors, epidemiology and genetic studies, and community-based clinical trials. *Prevention-oriented research*: primary and secondary prevention of disease in patients, and health promotion via behavioral modification.

† Clinical care providers refer to early career rheumatologists who deliver clinical services as an owner/partner of a solo or group practice, or are employed by a group practice, health system, or hospital.

‡Federal government: includes all early career rheumatologists employed by the Department of Health and Human Services (HHS), Department of Defense (DOD), and the Department of Veterans Affairs (VA).

§Academic medical centers refers to any medical school or teaching hospital accredited to sponsor a residency program in internal medicine or pediatrics, or a fellowship program in adult or pediatric rheumatology or both as approved by the Accreditation Council for Graduate Medical Education <http://www.acgme.org>.

Table 4. Analysis of proposals submitted and awards received by early career rheumatologists for post fellowship research training and research project grants.

Type of proposal or grant award	Sources of funding available to early career rheumatologists from the US						
	HHS*		VA*	DOD*	Philanthropy	Industry	Other
	NIH†	Other HHS†					
Training (post fellowship)							
Proposals/respondent‡	1.8 ± 0.3	0	1.4 ± 0.2	0	1.8 ± 0.2	2.6 ± 0.8	1.6 ± 0.2
Success/respondent (%)	41.2	---	20.0	---	NA§	NA	NA
Research as PI							
Proposals/respondent‡	2.8 ± 0.4	0.9 ± 0.5	1.1 ± 0.6	1.5 ± 0.5	2.7 ± 0.3	2.9 ± 0.5	1.8 ± 0.3
Grants /respondent‡	2.0 ± 0.3	1.3 ± 0.3	1.0 ± 0.1	0	2.4 ± 0.3	2.3 ± 0.4	2.0 ± 0.7
Success/respondent (%)	51.1	80.0	100	---	42.2	43.8	50.0
Research as Co-PI							
Proposals/respondent‡	2.4 ± 0.4	1.1 ± 0.9	0	0	2.1 ± 0.6	2.3 ± 0.7	4.3 ± 2.3
Grants /respondent‡	1.9 ± 0.4	0.6 ± 0.5	0	0	1.4 ± 0.7	2.0 ± 0.7	1.7 ± 0.9
Success/respondent (%)	45.8	75.0	---	---	50.0	41.6	40.0

* Federal departments: HHS-Department of Health and Human Services, VA-Veterans Affairs, and DOD-Department of Defense.

† NIH- National Institutes of Health, Other HHS: AHRQ- Agency for Healthcare Research & Quality, CDC- Centers for Disease Control & Prevention FDA- Food & Drug Administration, HRSA- Health Resources & Services Administration, and SAMSA-Substance Abuse & Mental Health Services Administration.

‡ Each value is expressed as the mean ± the standard error of either the mean or the mean percent. Estimates of proposals submitted for post-fellowship training are based on a cohort of 51 rheumatologists who produced 153 proposals from a sample of 239 eligible respondents. NIH post-fellowship data reflects K08/K23 proposals or awards.

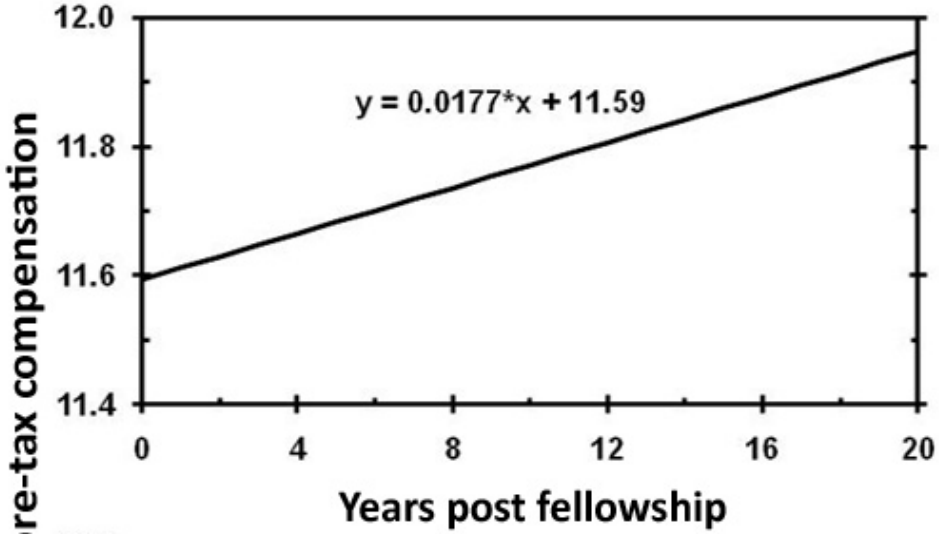
Estimates of proposals submitted for research project grants by PI's are based on a cohort of 38 respondents that submitted 233 proposals from a sample of 239 eligible rheumatologists. Estimates of proposals submitted for research project grants by Co-PI's are based on a cohort of 17 respondents who submitted 86 proposals from a sample of 239 eligible rheumatologists.

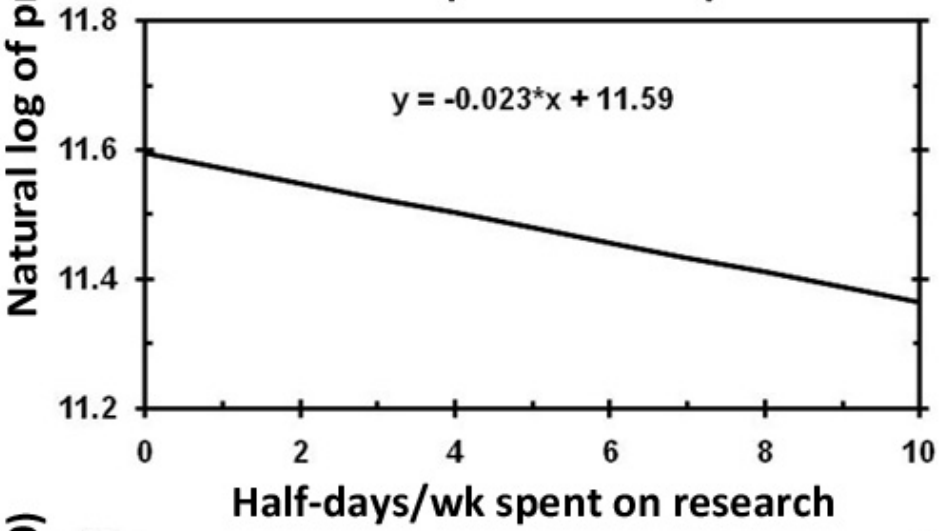
§ NA: data not available.

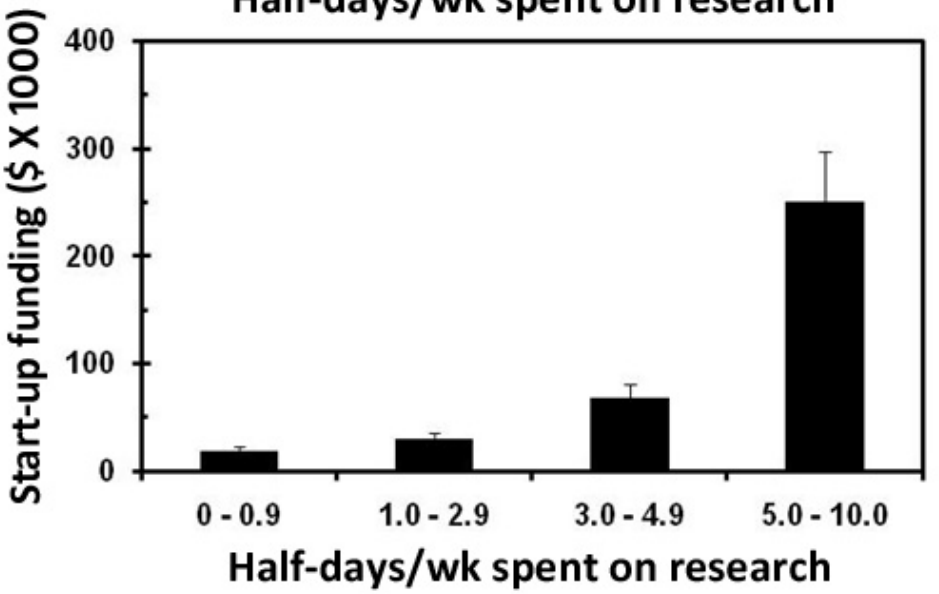
Fig. 1A-top. The equation/linear function describes the relationship between the natural log of pre-tax annual earnings and years post fellowship for early career rheumatologists. The equation/linear function demonstrates that mean annual pre-tax earnings increased by 1.8 % per year for each year of post-fellowship experience. The equation/linear function is based on a Tobit regression model that controlled for gender, total work time/wk, half-days/wk spent on research, and for bias occasioned by the non-reporting of some variables as noted in the Material and Methods.

Fig. 1B-middle. The equation/linear function describes the relationship between the natural log of pre-tax annual earnings and half-days/wk devoted to investigative work among early career rheumatologists. The equation/linear function indicates that mean annual pre-tax earnings decrease by 2.3% for each half day/wk spent on investigative work among early career clinical endocrinologists that spend two or more half-days/wk on research. The equation is based on a Tobit regression model that controlled for gender, total work time/wk, half-days/wk spent on research, and for bias occasioned by the non-reporting of some variables as noted in the Material and Methods.

Fig. 1C-bottom. Each bar designates the mean ± standard error of the mean of constant dollars invested in junior faculty as a function of the number of half-days/wk respondents spent on research. Institutional investments were based on the mean value of start-up packages (total institutional dollars [corrected to constant dollars] for personnel, equipment, supplies, and other research expenses) provided to early career rheumatologists employed at AMC's.


y = 0.0177*x + 11.59
Natural log of pre-tax compensation
12.0
11.8
11.6
11.4
0
4
8
12
16
20
Years post fellowship


y = -0.023*x + 11.59
11.8
11.6
11.4
11.2
0
2
4
6
8
10
Half-days/wk spent on research


Start-up funding ($ X 1000)
400
300
200
100
0
0 - 0.9
1.0 - 2.9
3.0 - 4.9
5.0 - 10.0
Half-days/wk spent on research