9-2009

The Scope and Scale of Clinical Research Accomplished by Rheumatologists Early in Their Careers

Claude Desjardins
University of Illinois Medical Center

E. William St. Clair M.D.
Duke University Medical Center

Ronald G. Ehrenberg
Cornell University, rge2@cornell.edu

The Scope and Scale of Clinical Research Accomplished by Rheumatologists Early in Their Careers

Abstract
[Excerpt] The scope and scale of clinical research is unknown for any medical or surgical specialty beyond snap shots of the broad aims and expenditures of research programs sponsored by federal agencies or the pharmaceutical industry. 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 is disabled. The present study was designed to examine the nature and extent of investigative activity prevailing among rheumatologists early in their careers. This assessment provides a lens on: i) the fraction of early career rheumatologists who engage in investigative rheumatology, ii) the scope and scale of research in musculoskeletal diseases, iii) funding available for investigative work, iv) the impact of "research-intensive" institutions, and NIH-K-series awards on research, and v) the demographic backgrounds of early career rheumatologists.

The results provide important new insights about the early career workforce for discovery and innovation in rheumatology. The findings integrate demographic, normative, and predictive data to provide the first estimate of the scope and scale of clinical investigation within rheumatology. The results also justify interventions for promoting investigative work, and ultimately advancing the clinical practice of rheumatology.

Keywords
rheumatologists, research, workplace, workforce

The Scope and Scale of Clinical Research Accomplished by Rheumatologists Early in Their Careers

CLAUDE DESJARDINS[1], E. WILLIAM ST. CLAIR[2], and RONALD G. EHRENBERG[3]

This research was supported, in part, by a grant from The American College of Rheumatology (ACR), Atlanta GA to defray the cost of producing and managing a web-based survey, and in part by the Cornell Higher Education Research Institute, Cornell University, Ithaca, NY. The ACR exercised no role in the design or analysis of this study, nor in the decision to publish the findings. The contents of this article are solely attributable to the authors, and do not reflect the views of ACR, any of its officers, or staff.

[1]Claude Desjardins, Ph.D., Clinical Scholars Project, CSN Building-M/C 955, University of Illinois Medical Center, 820 S. Wood Street, Chicago IL 60612-4325; [2]E. William St. Clair, M.D., Division of Rheumatology and Immunology, Department of Medicine, Duke University, Box 3874 Medical Center, Durham, NC 27710, [3]Ronald G. Ehrenberg, Ph.D., Cornell Higher Education Research Institute, 385A Ives East, Cornell University, Ithaca, NY 14853-3901.

Address for correspondence and reprint requests: Claude Desjardins, Clinical Scholars Project, CSN Building-M/C 955, University of Illinois Medical Center, 820 S. Wood Street, Chicago IL 60612-4325; E-mail: clauded@uic.edu

Objective. Assess the workforce and workplace for rheumatology, and the investigative work accomplished by rheumatologists early in their careers.

Methods. "Early career rheumatologists" are defined as physicians who joined ACR between 1991-2005, were under 49 years of age on joining ACR, and reside in Canada or the US. This cohort was invited to respond to a web-based survey distributed by ACR. A total of 247 survey instruments (21.2 % response rate) were used for this study. Survey questions were designed to obtain core insights about: i) the workforce, ii) workplace, iii) time devoted to administrative, clinical service, didactic, and investigative tasks, iv) types of investigative work accomplished, v) sources of funding for training and research, and vi) a demographic profile of respondents.

Results. Investigative work is pursued across all workplaces where rheumatologists are employed. Patient-oriented research predominates at 32 % followed by disease- and population-oriented studies at a respective 17 % and 13 %. Basic-, translational-, and prevention-oriented research was accomplished by a respective 9.6 %, 8.3 %, and 3.7 % of respondents. Clinical earnings underwrite about 40% of the salary costs for research, grants/contracts about 21.3%, and hospitals/medical schools about 14.5%. Completion of pre-and post-clinical training at "research-intensive" institutions is correlated with half-days/wk devoted to research ($P < 0.01$), and the receipt of a NIH K-08 grant is positively associated with receiving 2.8 federal research-project grants ($P < 0.001$). Rheumatologists associate research with lost earnings, a perception validated by an estimated reduction in pre-tax annual earnings of 2.3% for each half-day/wk dedicated to research ($P < 0.01$).

Conclusions. Over 80% of the early career workforce pursues investigative work, and human subjects are required for 90% of research projects. No measurable gender disparities were identified. Interventions are proposed to enhance the number of K-08 awardees; address disincentives for pursuing investigative work, recruit rheumatologists from underrepresented demographic groups, and improve funding within all domains of investigative rheumatology.

Clinical research commands a pivotal position in the overall structure of medicine for several reasons. First, and most important, 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 who 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 snap shots 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 is disabled (5-8). The present study was designed to examine the nature and extent of investigative activity prevailing among rheumatologists early in their careers. This assessment provides a lens on: i) the fraction of early career rheumatologists who engage in investigative rheumatology, ii) the scope and scale of research in musculoskeletal diseases, iii) funding available for investigative work, iv) the impact of "research-intensive" institutions, and NIH-K-series awards on research, and v) the demographic backgrounds of early career rheumatologists.

The results provide important new insights about the early career workforce for discovery and innovation in rheumatology. The findings integrate demographic, normative, and predictive data to provide the first estimate of the scope and scale of clinical investigation within rheumatology. The results also justify interventions for promoting investigative work, and ultimately advancing the clinical practice of rheumatology.

MATERIALS AND METHODS

Survey participants. The American College of Rheumatology (ACR) is the primary professional

organization (www.rheumatology.org) dedicated to advancing the clinical practice of rheumatology in North America. An agreement was established with ACR to distribute a web-based survey instrument---produced by the authors---to e-mail addresses maintained by ACR. A letter of invitation from ACR preceded respondent access to the survey instrument.

Rheumatologists, early in their careers, were identified for this study based on four criteria: joined ACR between January 1, 1991 and December 31, 2005, earned an M.D. or equivalent degree, reside in Canada or the United States, and were under 49 yr of age on joining ACR. A screening question was asked to verify whether respondents held a license to practice medicine in Canada or the US. Unlicensed respondents were thanked and excluded from participating in the survey to limit the findings to physicians qualified to direct clinical protocols involving human subjects.

The cohort of early career rheumatologists designated for this survey received an original email, and two follow-up email reminders if they failed to return a survey instrument between December 2007 and February 2008. A copy of the survey tool is available at <http://www.cornellsurveyresearch.com/sri/files/Rheumatology_Questionnaire.pdf>. A total of 265 rheumatologists accessed the hyperlink in the email message to participate in this study. Incomplete surveys were discarded making a total of 247 survey instruments available for assessment, and a final response rate of 21.2 %. The survey protocol adopted for this study is consistent with that used by ACR to survey members about services or issues pertaining to rheumatology. The mean response rate for three ACR surveys accomplished in 2007-2008 was 25.7 % (9), a value that approximates the response rate achieved for this study.

Instructions to survey participants indicated that the distribution of the survey questionnaire was approved by the Board of Directors of ACR, and that IRB approval was obtained, for an exempt protocol, from the Office for the Protection of Research Subjects, 203 Administrative Office Building, University of Illinois at Chicago, Chicago, IL 60612 (www.research.uic.edu). 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. Individual responses were submitted anonymously over the Internet. Survey security was maintained by directing responses over a secure server. Participant data, resided behind a firewall, on a secure server at the Survey Research Institute at Cornell University, Ithaca, NY (http://www.cornellsurveyresearch.com).

Design and content of survey instrument. A preliminary version of the survey instrument was tested for ambiguity and errors. A random sample of 50 rheumatologists, satisfying all "early career" criteria, was invited to respond to a draft version of the survey. Pilot survey participants were asked to comment on any question they perceived to be ambiguous, awkward, or impertinent. A total of 18 participants returned pilot surveys with comments that were used to reformat the survey instrument used in this study. The results of pilot surveys are excluded from the final results presented here.

The final version of the survey instrument invited participants to identify their place of employment, specify the number of half-days/wk devoted to clinical service, teaching, research, and administrative activities based on their supervisor's expectations, or themselves in the case of solo practitioners, designate 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 select one or more types of research that "best defined" their investigative work over the past 12 months. The menu of investigative activities---with definitions---included: *Basic research*: involves laboratory-based research including the development of new drugs, technologies, or devices. *Translational research*: entails bench to bedside or bi-directional research involving human subjects known to the investigator. Excludes the use of human specimens of cells/tissues for laboratory-based studies. *Disease-oriented research*: requires the use of human subjects to investigate the mechanisms or natural history of diseases, or improve the detection or diagnosis of a disease. *Patient-oriented research*: clinical trials, including Phase I, II, III, IV trials of drugs, and biologics, tests of devices, and the evaluation of therapeutic interventions. *Population-oriented research*: includes 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.

A series of positive and negative questions were asked to test commonly perceived disincentives for pursuing investigative work. This series of questions relied on a 4-point Likert scale (10). The scale was collapsed to limit the analysis to two outcomes: agree or disagree. A second series of questions was used to estimate the quality of institutional support available for clinical or laboratory research projects during residency and fellowship training. The third series of questions considered sources for funding available to rheumatologists who sought additional training to pursue investigative work. A final series of questions tested whether respondents submitted proposals and won grant/contract support for research projects in rheumatology either as a principle or as a co-principle investigator.

The demographic profile of rheumatologists, early in their careers, was examined by inviting respondents to designate their age, citizenship (Canada or US), gender, and ethnic origin. Other questions were used to identify the institutions where respondents earned their baccalaureate and medical degrees, where their residency and fellowship training was accomplished, and where they earned advanced degrees.

Analysis and interpretation of survey results. A unique case number was assigned to each survey instrument returned to the Survey Research Institute at Cornell University so individual responses would remain anonymous. Case numbers were used to evaluate the responses to all questions, determine the total number of responses to individual questions, and estimate the statistical attributes of each answered question.

The fraction of respondents whose pre- and post-clinical training occurred in the United States was studied in detail to test whether or not statistical correlations exist between training at "research-intensive" institutions and the performance of investigative work as measured by half-days/wk devoted to research

or the receipt of grants /contracts. The "research-intensity" of institutions where rheumatologists accomplished their pre- and post-clinical training in the United States were ranked as described next.

Institutions awarding baccalaureate degrees were assigned a program identification number designated by the Integrated Postsecondary Education Data System (IPEDS), Institute for Educational Statistics of the U.S. Department of Education (11). Unique identification numbers were assigned for colleges and universities with multiple campuses since admission criteria differ within multi-campus systems. Program identification numbers were used to establish the median SAT score of admitted or entering students from a database of 1,300 colleges and universities included in 2005 Annual Survey of Colleges (12). The median SAT score in this database is the midpoint of SAT scores falling within the 25th to 75th percentile range. This measure provides a reliable approximation of the median assuming that SAT scores within this range are not clumped at the endpoints for any given institution. Median SAT scores for individual institutions were ordered from highest to lowest and divided into ten groups with near equivalent frequencies to rank U.S. colleges and universities awarding baccalaureate degrees on a scale from 10 to1 with 10 assigned to the fraction of institutions with the highest median SAT scores. Equal observations, “ties”, where assigned the average rank of the group. In a few instances, institutional SAT scores were unavailable and required the substitution of ACT for SAT scores. This transformation was achieved by converting the reported institutional ACT score into an SAT score using the algorithm established for this conversion and published by ACT (13).

A similar 10-point scale was developed to rank U. S. medical schools. The unique program identification numbers for each medical school relied on those assigned by the American Association of Medical Colleges (14). Medical school rank was based on total dollars awarded to the nations 126 allopathic medical schools by the National Institutes of Health (NIH) for peer reviewed research grants/contracts (excluding awards for construction or training) funded in 1996, 2000, and 2005, respectively (15). Residency programs in internal medicine and pediatrics, and fellowship programs in adult and pediatric rheumatology were assigned unique program identification numbers based on those

designated by the Accreditation Council for Graduate Medical Education (ACGME, 16). All academic medical centers and teaching hospitals with approved residency and fellowship programs in rheumatology (internal medicine and pediatrics) were ranked on the previously described 10-point ordered scale, based on total dollars awarded to institutional program sponsors by the Department of Health and Human Services (HHS) for all agencies administering peer reviewed research grants/contracts (excluding construction or training awards) in 1996, 2000, and 2005, respectively (17). The ethnic backgrounds of allopathic medical school graduates in the United States were determined by estimating the mean distribution of each ethnic group reported for 1991 to 2005 from data compiled and published by the American Association of Medical Colleges (18).

Institutions awarding graduate degrees were assigned a unique program identification number designated by IPEDS (11). Graduate programs in the life sciences were ranked on a 10-ponit scale, previously described, using total federal obligations committed for research in the life sciences by both HHS and the National Science Foundation to 210 graduate institutions over three fiscal years: 1996, 2000, and 2005 (17).

Statistical methodology. Pearson's chi-square goodness-of-fit-test was used to determine whether or not the cohort of survey respondents and the population of respondents eligible for this study differed based on the following criteria: gender mix, age distribution, fraction of residents from states within the US, and the distribution of residents from Canada or the US. The results involving multiple comparisons across groups relied on testing whether the distribution differed across groups or in the case of means, whether the means differed across or between groups. Data involving frequency statistics, such as yes/no responses and the distribution of men and women, are compared via Pearson's chi-square goodness-of-fit-test. Statistical assessments involving means rely 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 research project grants by PI's and Co-PI's and other explanatory variables of research performance, and the "research-

intensity" of each of the intuitions individual respondents attended for their baccalaureate, M.D. degree, residency, and fellowship. The probability of regression coefficients relies on the assumption that variables are distributed randomly. The assumptions underling the adoption of an unmodified ordinary least squares model include linearity, full rank, exogeneity of independent variables, homoscedasticity of error terms, and exogenously generated data. The results are reported as two-sided P-values with estimated confidence intervals.

We used a Tobit regression model to determine the association between pre-tax annual earnings and various outcome measures since this model accommodates 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. We justified this transformation on the basis that rheumatologists who are unengaged in research would likely overlook the need to document a zero response.

All statistical assessments were achieved using software produced by Stata (version 6.0, Stata, College Station, TX).

RESULTS

Survey sample. This report is based on a cohort of 247 rheumatologists, early in their careers, who completed and returned survey questionnaires considered for this study. The cohort of actual respondents was compared with the sample of eligible participants to test whether or not the two groups differed on the basis of age, gender, state of residence, and country (Canada and United States). The results indicate that the four tested criteria were similar ($P > 0.20$) for the cohort of expected and actual respondents, evidence that the participants who took part in this study are representative of ACR members, early in their careers.

Pre- and post-clinical training in rheumatology. A significant number ($P < 0.05$) of early career rheumatologists completed their preclinical training outside of North America. The percent of respondents earning a baccalaureate degree from an institution in the US, Canada or an international location or was 84.3 %, 5.2 %, and 10.5 % respectively. A respective 75.5 %, 4.6 %, and 19.9% of respondents earned an MD or equivalent degree from a US, Canadian, or international institution. Residency and fellowship training, as expected, was accomplished in North America with 98.6% of the respondents trained in Canada or the United States.

Respondents completed medical school at 27.1 ± 0.2 years of age (mean ± SEM) and finished fellowship training at an average of 33.7 ± 0.2 years, an elapsed interval of 6.6 ± 0.2 years. The mean age at which women and men concluded their pre-and post-clinical training was nearly identical. The results establish the lack of any significant gap in the time required to finish residency and fellowship programs in rheumatology, and document that early career rheumatologists enter the workforce at a mean age of 33.7 years to provide clinical care or pursue clinical research or both. Further, about 99% of the respondents report that they are board certified or board eligible in either adult or pediatric rheumatology, an indication that the training of rheumatologists in this study was remarkably homogenous.

Demographic profile of rheumatologists. The distribution of respondents residing in the United States and Canada was a respective 95% and 5%. The mean fraction of citizens, permanent residents, and non-citizen respondents from the United States was on the order of 85.8 %, 8.5 %, and 5.7 %, respectively. The fraction of citizens, permanent residents, and non-citizens among Canadian members of ACR was nearly identical to that of rheumatologists residing in the United States ($P > 0.50$).

The gender of early career participants, from the United States, was 44.8 % women and 55.2 % men. All other demographic measures (age, gender, ethnic background) of respondents from the United Sates and Canada were similar ($P > 0.50$), an indication that the cohort of early career rheumatologists, from both countries, are indistinguishable for the purposes of this study.

The self-identified ethnic backgrounds of rheumatologists, early in their careers, is shown in Table 1 for comparison with that of US medical school graduates over the same 15 year sample interval (1991-2005) adopted for this study. The fraction of respondents from Asian and Hispanic or Latino backgrounds approaches that of US medical school graduates (Table 1). The number of Black or African American rheumatologists, in contrast, is underrepresented in the survey sample by about 6.5% while the number of Caucasians is overrepresented by the same amount, when compared with the population of students (mean of 15,713/yr) earning an M.D. degree in the 15-year interval between 1991 and 2005 (Table 1).

Workplace assessments. The amount of time early career rheumatologists spend on clinical service, teaching, research, and administrative work was estimated by asking respondents to specify the number of half-days/wk devoted to each activity based on the percent effort they negotiated with their supervisor in the immediate 12 months preceding the survey (Table 2). Respondents were cautioned exclude "off-the-clock" work-related activities that might take place on evenings, weekends, or holidays. Thus, the results reflect the distribution of work accomplished by rheumatologists over a putative 40 hr workweek, the federal standard for reporting time/effort across all employment sectors in the US (Table 2).

The findings document that clinical service is accomplished across all workplaces where rheumatologists are employed (Table 2). Respondents employed in a solo or group practice, health system, or hospital, however, place a premium on providing clinical care as evidenced by an average commitment of about 7.9 half-days/wk. In sharp contrast, a respective 3.5, 2.3 and 1.5 half-days/wk are devoted to clinical service among rheumatologists employed in academic medical centers, the federal government, and the pharmaceutical/biotech industry (Table 2).

Early career rheumatologists, from all workplaces, are involved in teaching medical students, residents, and fellows (Table 2). Respondents employed by academic medical centers report teaching about 1.5 half-days/wk while clinical care providers, federal employees, and those in the pharmaceutical/biotech industry spend similar---0.4, 0.6 and 0.5 half days/wk---but, significantly less time ($P < 0.01$) teaching than counterparts in academe (Table 2).

Clinical care providers devote an average of 1.4 half-days/wk to investigative work. But, research studies occupy an average of 4.0 half-days/wk among rheumatologists in academic medical centers, and a respective 4.8 and 5.1 half days/wk for those employed in the federal and pharmaceutical/biotech sectors (Table 2). Administrative duties require an average of 0.8 half days/wk among clinical care providers, 1.5 half days/wk in the academic and federal arenas, and about 3.8 half days/wk in the pharmaceutical/biotech industry (Table 2).

Scope and scale of investigative activities. Analysis of the types of investigative work accomplished by rheumatologists, early in their careers, established that patient-oriented research is the predominant activity ($P < 0.01$) exceeding the commitment to either disease- or population-oriented research by 2.5-fold (Table 3). Basic, translational, and prevention-oriented research each involved comparable levels of effort ($P > 0.25$), but the time devoted to these activities is only a fraction of 1 half-day/wk (Table 3) when these activities are examined independent of workplace.

Investigative work was accomplished by about 84% of respondents in the 12 mo preceding the survey (Table 3). Respondents pursued both basic and clinical research, but placed a premium ($P < 0.001$) on studies requiring human subjects (Table 3). No gender disparities are evident ($P > 0.25$) among the fraction of early career rheumatologists that report being uninvolved or involved in any of the investigative pursuits examined here (Table 3).

The workplace for investigative rheumatology was dissected by employment sector, namely: academic medical centers (AMC'), clinical practice settings, the federal government, and the pharmaceutical/biotech industry (Table 3). Within the clinical care workplace, research is pursued by about 69% of specialists albeit at percentages below those of rheumatologists employed in workplaces offering dedicated time for research (Table 3). The clinical care workplace emphasizes patient-oriented studies, primarily, and disease- and population-oriented research, secondarily (Table 5). Tertiary attention is given to basic, translational- and prevention-oriented research, but only token efforts are devoted to the later three activities (Table 3).

Workplaces sponsored by the federal government and the pharmaceutical/biotech industry engages in similar lines ($P > 0.15$) of investigative work (Table 3). The investigative portfolio of the academic workplace differs from all other employment sectors because commitments are dispersed among multiple activities (Table 3). For instance, patient- disease- and population-oriented research are the most prevalent activities, but the fraction of effort devoted to each activity is similar amounting to about 20%. Basic- and translation-oriented research explain 12% to14% of investigative work with a remaining 4% devoted to prevention-oriented research (Table 3).

The sources of money used to underwrite the salaries of early career respondents were assessed to establish the salary support for investigative work in rheumatology. Clinical earnings are the primary source of funds used to defray the salaries of investigative rheumatologists, early in their careers, and account for about 39.7 % of the total dollars driving the investigative enterprise. Grant and contract funding, in contrast to clinical income, covered about 21.3 % of the salary costs for research studies. Intramural funding sources (medical schools/hospitals) finance about 14.5% of investigative labor costs while endowments and income from "other" sources cover about 8.3 % of research salary costs. Rheumatologists employed by the federal government and the pharmaceutical /biotech industry explain a respective 8.3 % and 7.9 % of the salary dollars supporting innovation and discovery in rheumatology. No gender differences are evident in the source of funds committed to underwrite the salaries of early career rheumatologists engaged in scholarly work ($P > 0.25$).

The submission of proposals and the receipt of grants by principal (PI) and co-principal investigators (Co-PI) are summarized in Table 4. A total of 53 early career rheumatologists produced 153 proposals for post-fellowship research training (Table 4). Approximately 13.1 % of post-fellowship training proposals were prepared to gain funding for an NIH K-08 mentored scientist award. An average of 1.8 K-08 proposals were submitted per applicant with a success rate of 41.1% per respondent or 22.2 % per application (Table 4). Far fewer training proposals are submitted to the VA, in comparison to NIH, and the success of these proposals is about 20.0 % per respondent (Table 4).

Survey respondents produced over 300 proposals to obtain funding for research projects either as a PI or a Co-PI (Table 4). About one-third of investigator-initiated proposals were submitted to NIH, one-third to industry, and one-third to philanthropic sources (Table 4). Prospective PI's submitted an average of 2.8 proposals to NIH, and received 2.0 awards per respondent for a success rate of 51.1 % per respondent or 31.1% per application (Table 4). Fewer proposals were submitted to non-NIH HHS agencies and the VA, but the mean success rate per respondent was greater ($P < 0.05$) than that reported for NIH awards (Table 4). The success rate of PI produced proposals considered by philanthropic sources, industry, and other funding sources were a respective 42 %, 43%, and 50% (Table 4). Co-PI proposals considered by federal and non-federal agencies achieved funding at about the same level ($P > 0.15$) as those submitted by PI's (Table 4).

We determined whether or not a correlation exists between a respondent's training at "research-intensive" undergraduate institutions, medical schools, residency programs or fellowship programs and the receipt of research project grant awards either as a PI or Co-PI (Table 5). More specifically, we considered federal and total grants awarded to both PI's and Co-PI's as dependent variables in multiple regression analyses, while the explanatory variables included estimates of institutional "research-intensity" at each of the four specific stages of the individual's training, as well as gender, years post-fellowship, earning an advanced degree (M.S., M.P.H., Ph.D.), and the number of half-days/wk devoted to research. An additional model was used to estimate an average measure of respondent training at "research-intensive" institutions. Quite striking, multiple regression analysis indicated that only the number of half-days/wk devoted to research was related to grant award measures. The award of research project grants was unrelated to an individual's gender, years post-fellowship, earning an advanced degree (M.S., M.P.H., Ph.D.) or the "research-intensity" of institutions, at any of the four stages of the individual's training. All measures of "research-intensity," however, are positively correlated with the number of half-days/wk early career respondents dedicate to research when the explanatory variables are years post-fellowship and the "research-intensity" of institutions at which respondents are trained, (Table

5). Put simply, the "research-intensity" of institutions---at each stage of an individual's training---is correlated with the number of half-days/wk devoted to research, which in turn is related to the number of research grants received by PI's and Co-PI's.

The receipt of an NIH K-08 award, however, is a consequential marker of research project grants awarded to both PI's and Co-PI's from federal and nonfederal sources ($P < 0.001$). Specifically, early career rheumatologists receiving a NIH K-08 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.

Fostering innovation and discovery in rheumatology. Respondents were queried about their interest in pursuing a career involving research when they were first year medical students, residents, and fellows. The fraction of positive responses (yes) increased linearly from about 28 % for medical students, 38 % for residents, and 60 % for fellows. The same cohort was asked to indicate whether opportunities to participate in a faculty-directed research project were well advertised when they were medical students, residents, and fellows. Approximately 75 % of respondents reported that mentored research projects were not well advertised when they were medical students and residents. But, only about 33 % of first-year fellows indicated they were unaware of opportunities to participate in a faculty-mentored research project.

Potential disincentives for pursuing an investigative career were examined to consider interventions for rebooting enthusiasm for clinical research (Table 6). Approximately 75 % of respondents perceived that clinical investigators are undercompensated relative to rheumatologists who place a premium on providing clinical care ($P < 0.01$). A greater number of respondents, 80 %, report that investigative careers are unattractive relative to those dominated by clinical service because of the expectation to produce publications and prepare proposals to gain funding for clinical or basic studies ($P < 0.01$). About 72 % of respondents noted that job security is a significantly greater risk for clinical investigators than for clinical care providers ($P < 0.01$). Interestingly, the time and intellectual energy required to pursue a successful career in clinical investigation was not perceived to be any more burdensome than that required for a successful career emphasizing clinical service (Table 6).

The perceived undercompensation of investigative rheumatologists reported in Table 6 was examined, in greater detail, by using a Tobit regression model that specified that 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, type of employment, and total work hours per week. The results indicate that pre-tax annual earnings increased linearly at an average of 1.8 %/yr with each year of post fellowship experience (Fig. 1). Rheumatologists who devote 2 or more half-days/wk to investigative work, in salient distinction, are undercompensated by about 2.3 %/yr for each half-day/wk spent on research ($P < 0.01$) relative to cohorts devoting1 half-day/wk or less on investigative work (Fig.2).

Institutional commitments to investigative rheumatology. Institutional support for investigative rheumatology was estimated by using the total dollar value of start-up packages provided to rheumatologists, early in their careers, for personnel, equipment, supplies, and other research expenses. The results indicate a linear relationship between the number of half-days/wk devoted to research and institutional investments made to support the nascent research programs of rheumatologists early in their careers (Fig. 3).

The availability of tenure-track positions was estimated for the fraction of respondents employed in academic medical centers. Tenure opportunities are limited to about 50% of the institutions where early career rheumatologists are employed. An estimated 53.2 % of women and 46.8 % of men work at AMC's granting tenure. Approximately 40. 2 % of women and 59.5 % of men held tenure-eligible faculty appointments, a differential that was not significant ($P > 0.12$).

DISCUSSION

The results of this study provide important new information about the workforce and workplace for rheumatology, and offer fresh insights about the scope and scale of clinical research in rheumatology.

The findings also furnish a rational framework for designing interventions to enhance the investigative enterprise and ultimately transform the clinical practice of rheumatology.

The present assessment of rheumatologists, early in their careers, relied on self-reported responses to a Web-based questionnaire. Surveys provide the only logical mechanism to examine a workforce engaged in disparate activities, and assess workplaces that are decentralized across North America. The reliability of self-reported estimates of individual performance and personal experiences has been verified exhaustively (19). Tests of the credibility and validity of survey responses emphasize that conclusive data relies on multiple criteria (20), namely: i) asking clear and unambiguous questions, ii) limiting queries to information respondents readily know, iii) confining questions to recent events or well established routines, iv) restricting questions to those with high face and content value, and v) avoiding responses that threaten, violate privacy, or elicit professionally or socially desirable responses.

The Web-based questionnaire adopted for this study was designed to satisfy each of these conditions. Further, a prototype of the survey tool was sent to 18 rheumatologists meeting all of the criteria for participating in this study. This cohort was invited to take the survey, and provide written comments on any question that appeared troublesome, offensive, or ambiguous. The final version of the survey tool was amended to address the apprehensions of pilot test volunteers. Importantly, the gender mix, age distribution, location of states within the US, and country of residence of survey participants were comparable ($P > 0.20$) to the cohort of rheumatologists eligible to return a survey questionnaire. The concordance between expected and actual survey respondents offers assurance that the present findings typify the experiences of early career rheumatologists from Canada and the United States. It seems reasonable to assert, therefore, that the present survey protocol provides the framework to formulate meaningful insights about the experiences and training of rheumatologists, in general, and the cohort of rheumatologists engaged in innovation and discovery, in particular.

The results offer a contemporary snap shot of the fraction of time devoted to clinical service, teaching, research and administrative tasks among rheumatologists early in their careers. First, the number of half-

days/wk spent on each task is employer dependent (Table 2). Second, teaching and administrative responsibilities are accomplished within each of the four workplaces (Table 2). The half-days/wk devoted to these two tasks, however, are clearly secondary to either clinical service or research or both depending upon the particular work place. Third, the clinical service workplace is defined by a 75 % effort to patient care, a singular time commitment not evident in any other workplace (Table 2). Last, in other workplaces, time is dispersed among the four types of tasks with research emerging as the dominant activity, but only on the order of 39 % to 45 % effort (Table 2). Among the workplaces that champion clinical investigation, rheumatologists in the academic sector devote less time to research than colleagues affiliated with either the federal or pharmaceutical sectors (Table 2).

The finding that academic rheumatologists devote an average of 45 % effort to investigative work was unanticipated given that early career faculty are advised to spend about 75 % effort on research to develop their research program (21-22). The present results imply that opportunities to pursue investigative work are hampered by one or more of the following: institutional priorities, the need to generate earnings closer to those of full-time clinical providers through clinical service, life style preferences, and the unreliable or problematic support for clinical research that is available from grants and/or contracts awarded by federal agencies.

The type of investigative work pursued by rheumatologists, early in their careers, was defined by inviting respondents to specify their involvement in one or more of the following: basic-, translational-, disease-, patient-, population-, and prevention-oriented research. The findings offer new perspectives about the scope and scale of investigative work within each of these domains. The results document that human subjects are required for over 90% of the research pursued by rheumatologists, early in their careers (Table 3). It is critical to note that the survey tool advised respondents to distinguish between laboratory-based and clinical studies involving the use of human subjects known to the investigator (Table 3). Next, patient-oriented research is the predominant investigative activity pursued across all workplaces (Table 3). All workplaces focus comparable attention on disease- and population-oriented

research. Both of these activities, however, are subordinate to patient-oriented work. The percent effort devoted to translational-, and basic-oriented research is analogous among workplaces, but the commitment to these two lines of work is only a fraction of that made to the other types of clinical studies considered here. Prevention research is the least prevalent activity with little or no effort reported for any workplace (Table 3).

The premium placed on patient- and disease-oriented studies in the clinical care workplace underscores the interest and opportunity of early career rheumatologists to direct clinical protocols or participate in multi-center clinical trials of new drugs and procedures sponsored by either federal agencies or the pharmaceutical/biotech industry or both. This assertion is based on two lines of evidence, namely: i) research is the second most prevalent activity among clinical care workforce, and ii) about 70% of the clinical care workforce participates in investigative work. These results, considered together, indicate that the provider workforce is a previously undocumented but formidable cadre of investigators who advance the clinical practice in rheumatology by fixing their attention primarily on patient- and disease-oriented research.

Research is the predominant commitment within workplaces supported by the federal government and the pharmaceutical/biotech industry, and both workplaces exploit similar investigative strategies (Table 3). The primary distinction between the two workplaces resides in the commitment of the pharmaceutical/biotech industry to translational research, an effort exceeding that of all other workplaces (Table 3). Research in the academic workplace is best described as multi-focal where investigative attention is disbursed among all lines of work. Similarities in the scale of the investigative effort within the academic research enterprise emphasize its breadth in contrast to the programmatic specificity noted in each of the other workplaces (Table 3).

The inattention accorded to prevention research, across all workplaces, was unexpected given the suite of emergent technologies designed to estimate an individual's risk for developing diseases, the opportunity to prevent disease onset, and the possibility of intervening at the earliest possible time when

disease occurs (23-24). Contemporary investigative rheumatology is replete with strategies for exploiting the tools of genomic medicine---risk assessment, disease tracking, and personalized therapy---to prevent the chronic disabilities occasioned by connective tissue disorders (25-27). Federal and philanthropic stakeholders in rheumatology should view this clinical gap as an opportunity to developing a set of interventions aimed at targeting significant new monies for prevention-oriented research with the goal of stimulating interest in prevention-oriented work with the objective of transforming medical care for patients with rheumatoid diseases.

Analysis of the sources of money used to compensate early career rheumatologists for the fraction of time spent on research indicates that clinical earnings prevail as the chief source of funds with about 40 % of research salary costs paid through clinical service. Grant and contract funds, in sharp contrast, only cover about 20 % of the salary expenses for research. Medical schools and/or teaching hospitals underwrite about 12 % of the salary costs for doing investigative work, and about 7% is paid from other unspecified sources. Research salary subventions, awarded by medical schools/hospitals, are limited, and intended as short-term investments for launching the careers of new faculty or to provide bridge funding for established faculty who have temporarily lost salary support.

The present results indicate that clinical earnings play a critical role in supporting the investigative work of academic rheumatologists early in their careers. The need to rely of clinical income, as apposed to funding derived from to extramural grants or contracts, has several unintended consequences for investigative rheumatology, namely: i) innovation and discovery is hobbled by delaying or possibly preventing therapeutic advances for the clinical management of arthritis and other rheumatic conditions, ii) high reward studies involving contemporary technologies are abandoned or postponed delaying a shift in the paradigm from curative to preemptive rheumatology, and iii) basic scientists are unaware of technical gaps in clinical studies that must be overcome to develop new therapeutic and preventative strategies. These unintended outcomes are traceable, in part, to an approximate disparity in funding of 65:35 for basic versus clinical studies by federal agencies (28), and, in part, to a steadily evolving

dysfunction in the federal-institutional partnership for clinical investigation recently detailed by Crowley et al. (29).

The analysis of research project proposals produced by early career rheumatologists offers important new information about the fraction of early career rheumatologists who compete for extramural research support as PI's or Co-PI's (Table 4). The findings establish that about 21% of early career respondents submit investigator-initiated research project applications for research projects to federal and non-federal agencies in approximately equivalent proportions (Table 4). The outcome of applications submitted by PI's and Co-PI's are decidedly successful as determined by the receipt of about 2.0 NIH research project grants for both PI's and Co-PI's during their early careers (Table 4). Finally, the results indicate that neither an advanced degree (M.S., M.P.H., Ph.D.) nor training at "research-intensive" institutions is correlated the receipt of grants from federal or nonfederal sources by either a PI or Co-PI (Table 5). Affiliation with "research-intensive" programs, however, is correlated ($P < 0.001$) with the number of half-days/wk devoted to investigative work (Table 5), a finding that is consistent with data documenting that more than 80 % of the early career workforce is committed to investigative work.

Proposals for post-fellowship research training were produced by about 20 % of respondents for consideration by federal, philanthropic, and industrial funding sources (Table 4). An estimated 13 % of respondents produced applications for NIH-K-08 mentored scientist awards with an approval rate of 41 % per respondent or about 22 % per individual application since an average of 1.8 applications is required to achieve funding (Table 4). The novel finding, based on assessing K-08 awardees, is the compelling association ($P < 0.001$) between receiving a NIH K-08 award and the subsequent award of an estimated 2.8 NIH research project grants. This outcome provides the rationale for considering interventions that would encourage a fraction of physicians, from research-oriented backgrounds, to acquire preliminary evidence for submitting a K-08 application at the earliest possible stage of their careers. We must acknowledge, however, that the present study was not designed to control for all of the possible variables needed to predict the success of K-awardees as future recipients of federal research grants. Nevertheless, a

demonstration project, involving a small number of rheumatologists---from research oriented programs---seems justified to test whether or not participation in "research-intensive" programs is a causal factor in shaping the success of K-awardees as future recipients of federal research project grant awards.

Past support for K-08 awards by the National Institute of Arthritis Musculoskeletal and Skin Diseases (NIAMS) appears modest as judged by an average award rate of 7.7 applications per year made between 1997-2005 for all subspecialty physicians supported by this institute (30). Based on the success of the K-awardees noted here, it seem reasonable to suggest that NIAMS increase its investment in K-08 funded rheumatologists from about 4 % of the estimated 190 rheumatologists that seek post fellowship training per year to accommodate between 5% to 6% of the emerging crop of fellows or about 10 rheumatologists per year. Further, it may be sensible for the ACR to consider an intervention project designed to improve the success of initial K-08 applications by implementing a mechanism to vet first-time applications for NIH K-08 projects prior to formal submission. The goal of the proposed intervention is to eliminate both the wasted time and investigative inertia attending the resubmission of a revised K-08 application. The proposed intervention would compliment and extend ACR's ongoing initiative to award bridge funds and vet the revised applications of mid-career rheumatologists who seek to transition from a K-08 to a K-23 award.

The time required to complete pre- and post-clinical training in rheumatology was examined to determine whether any significant gaps are evident in the education or training of early career rheumatologists. Women and men finished the prototypical 14-year training interval at similar ages and without any detectable delay ($P > 0.25$) starting with the onset of study for a baccalaureate degree and ending with the completion of fellowship training. These findings document the remarkable efficiency of programs for educating/training rheumatologists, and emphasize the abiding commitment made by rheumatologists to focus and finish their training assiduously. The temporal consistency observed in the education and training of rheumatologists suggests that a selected fraction of fellows interested in applying for NIH K-series awards should be encouraged to submit applications during the final year of

fellowship training. This small but significant cohort of applicants would be positioned to receive a 5-year NIH-K-series award within 1 year or less after finishing a fellowship, or at about 35 yr of age. They world then be ready to apply for their first NIH R01 award at an average age of 39 yr, or about 5 years earlier than the reported mean of about 44 yr that is typical of physicians who were first-time recipients of NIH R-01 research project grants in 2008 (31). In this context, the results establish that there is ample room to improve the pipeline of prospective K-08 awardees by informing and encouraging medical students, residents, fellows to participate in faculty mentored research projects with an eye toward gaining the prerequisite experience and knowledge for producing a successful proposal for an NIH K-08 award.

Turning to disincentives for pursuing an investigative career, survey participants perceived a decided fiscal penalty for engaging in investigative work (Table 6). The reality of this perception was verified by showing that pre-tax annual earnings are reduced by 2.3 % for each half-day/wk devoted to investigative work among early career rheumatologists who spend 2 or more half-days/wk on research (Fig 2). The estimated fiscal burden for engaging in investigative work was determined by logistical multiple regression equations that controlled for gender, employer, total work time per week, and half-days/wk spent on research, and years post-fellowship so the findings would not be confounded by the significant fraction of early career respondents whose careers are just underway.

Other disincentives for pursuing investigative work focused on the declining availability of tenure-track positions among academic employers, a finding that is consistent with an ongoing decrease in tenure-track appointments for clinical faculty within academic medical centers (32). The erosion in tenure-track positions in academic medical centers is tied to a perceived lack of job security when compared with employment as an owner/partner of a solo or group practice, or employment in a group practice, health system, or hospital. The overt concern with job security noted in the present survey is compelling and parallels the results of a recent report assessing the underperformance of clinical research in academic pulmonary medicine (33). Contemporary concerns with job security are not new, but remain among the most pernicious issues challenging medical schools since the heroic age of American medicine

(34). Institutions seeking to recruit and retain the most talented clinical scholars should examine their history of job security and compensation to address the documented disincentives reported here by rheumatologists early in their careers.

The results demonstrate that the self-identified ethnic backgrounds of survey respondents approximate those of physicians graduating from allopathic medical schools in the United States between 1991-2005 (Table 1). Two noteworthy disparities exist, however. First, the fraction of Black or African American rheumatologists detected in this survey is about 6% below the benchmark set by graduates of the nations medical schools (Table 1). Next, the percentage of rheumatologists who self-identify as Caucasian is approximately 6% above the mean for this cohort of graduates from US medical schools (Table 1).

The under representation of rheumatologists, from any ethnic background, is of intrinsic significance to investigative rheumatology. This issue merits deliberate and resolute attention because the ethnic background of physicians directing clinical protocols shapes the ethnic profile of volunteers agreeing to participate in a clinical trial or study (35-37). The acknowledged low rate of minority participation in clinical studies is exacerbated, in part, by the paucity of physicians from underrepresented ethnic groups who direct translational-, disease-, and patient-oriented research projects (35-36). The participation of underrepresented ethnic groups in clinical trials and studies is essential (35) since reliable estimates of the safety and efficacy of new and existing drugs or treatments are unachievable unless the participants in clinical trials mirror the demographic profile of the US population at large (35). Addressing racial/ethnic disparities in clinical trials in rheumatology is a persistent and evolving problem beyond the scope of this study (37). But, the need to reconcile ethnic disparities in the future workforce for rheumatology is an emergent concern pertinent to investigative rheumatology and the delivery of rheumatologic care to all demographic groups. Disparities in the ethnic backgrounds noted here point to the possibility of implementing interventions to recruit future generations of rheumatologists that approximate the demographic norm of graduates from the nations medical schools (18). The rationale behind the proposed intervention is consistent with the recommendations of several national efforts designed to facilitate the

inclusion of all demographic groups within highly trained scientific workforces including those for medicine (38-40).

Several general principles are warranted based on the present analysis of the scope and scale of investigative work accomplished by rheumatologists early in their careers. First, women represent an increasing and nearly equivalent segment of the workforce for rheumatology (41-42). Importantly, the present assessment of the workforce and workplace failed to uncover any evidence of gender disparity.

Second, the results emphasize that the commitment of early career rheumatologists to clinical research is more robust than expected from databases maintained by professional organizations (43) or from estimates of NIH awards made to physicians whose clinical specialties and investigative work is undefined (44). The prevalence of investigative work accomplished, across all employment sectors, in rheumatology points to the importance of designing future studies to dissect both the workforce and workplace, rely on a broad assessment of investigative activities within all workplaces, and allow physicians to self-define their recent commitment to administrative, clinical, didactic, and investigative work.

Understanding the fraction of the workforce engaged in investigative rheumatology is of utmost importance because this cohort drives clinical progress, and ultimately shapes patient care by extending therapeutic options through the application of advances in diverse disciplines such as autoimmunity, inflammation, genetics, pharmacogenomics, and risk assessment. The significance of this "rare" cohort on rheumatology is profound, and far exceeds their numbers within the workforce since a single contribution offers the potential of benefiting thousands of patients by transforming the clinical management of a particular disease. It is no exaggeration to anticipate that the demand for innovation and discovery in rheumatology will remain robust given the growing incidence of musculoskeletal disease in an aging US population, and the emerging opportunities to achieve preemptive medical care (23).

Third, opportunities to achieve clinical innovation and discovery in rheumatology are increasing exponentially with the proliferation of clinical proteomic and biomarker technologies for the diagnosis

and treatment of disease, monitoring patient responses to therapeutic agents, and even preempting certain arthritic and rheumatoid conditions (25-27). Rheumatology could well be at the forefront of developing, testing, and applying these emergent technologies with the ability to target particular subsets of patients with occult autoimmune conditions that are manifested as rheumatoid disease and are currently a challenge to treat and manage (45). All stakeholders within rheumatology--- academic, federal, industrial, philanthropic, professional---have the opportunity to accept the challenge and provide the leadership to promote prevention research as a core theme within investigative rheumatology. This action has the potential to reboot investigative rheumatology, and ultimately transform clinical practice from disease-based medicine to prospective health care with personal health care planning (23).

Fourth, the results provide a succinct snap shot of contemporary challenges facing the federal-institutional partnership for clinical investigation. On the one hand, extramural investigative partners are driven to devoting increased time to clinical service to generate clinical income for underwriting the cost of investigative work early in their careers. On the other hand, federal partners accede they have had persistent difficulty supporting clinical research (46), an acknowledgement that is consistent with documented disparities in funding of basic over clinical studies (29,47), achieving sapient integration of clinical research among agencies within the Department of Health and Human Services (29), and the lack of a palpable national commitment to transform medical practice from curative to preemptive over the approaching decade (48). These conclusions are not intended to detract from recent initiatives, championed by NIH (49,50), to improve the climate for clinical scholarship. Simply put, this overview provides the template for initiating a national dialog designed to integrate the coordination and collaboration of future investigative strategies in rheumatology, and to develop a fundamentally new model for funding a future workforce prudently and amply to expand therapeutic and preventive options for an unfolding array of rheumatologic conditions affecting children and adults. Only then will a bright future be assured for invention and creativity 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.

Statistical analysis. Desjardins, Ehrenberg.

ACKNOWLEDGEMENTS

The authors thank each of the rheumatologists who took the time to respond and return a survey questionnaire. La Tanya Batts and Steve Blevins at the American College of Rheumatology assisted with all phases of this project including the selection of rheumatologists designated for the preliminary and full surveys, and the distribution of survey materials.

Thanks are also due the staff of the Survey Research Institute at Cornell University <http://www.sri.cornell.edu> for programming and administering the survey, and to Kenneth T. Whelan, Cornell Higher Education Research Institute, Cornell University, Ithaca, NY for managing the statistical analysis of the entire survey project.

The senior author acknowledges the encouragement provided by Gerald S. Moss, M.D, Dean, College of Medicine, and University of Illinois at Chicago for his early endorsement of the clinical scholars project. Others in the Office of the Dean, College of Medicine, University of Illinois at Chicago, recognized the significance of this line of research and supported it throughout, including, A. Dontes, J. Flaherty, and S.J. Kilpatrick.

REFERENCES

1. Helmic CG, Felson DT, Lawrence RC, Gabriel S, Hirsch R, Kwoli CK, et al. Estimates of the prevalence of arthritis and other rheumatic conditions in the United States: Part I. Arthritis Rheum. 2008;58:15-25.

2. Kington RS. Biennial report of the director, National Institutes of Health, Fiscal Years 2006 & 2007. http://biennialreport.nih.gov. Accessed July 23, 2009.

3. Katz SI. Long-range plan: National Institute for Arthritis and Musculoskeletal and Skin Diseases for FY2006-2009. http://www.niams.nih.gov/About_Us/Mission_and_Purpose/intro_letter.asp. Accessed July 23, 2009.

4. Pharmaceutical Research and Manufacturers of America, Pharmaceutical industry profile 2008 (Washington, DC: PhRMA, July 23, 2009).

5. Wyngaarden JB. The clinical investigator as an endangered species. N Engl J Med. 1979;301:1254-59.

6. Rosenberg L. Physician-scientists–endangered and essential. Science. 1999;283:331-32.

7. Nathan DG. Careers in translational clinical research–historical perspectives, future challenges. J Am Med Assoc. 2002;287:2424-27.

8. Donowitz M, Germino G, Cominelli F, Anderson JM. The attrition of young physician-scientists: problems and potential solutions. Gastroenterology. 2007;132:477-80.

9. Batts L. Director, Research and Training, American College of Rheumatology, Email of April 1. Atlanta (GA): 2009.

10. Trochim W. The research methods knowledge base, 2nd ed. Cincinnati (OH): Atomic Dog Publishing; 2000.

11. U. S. Department of Education, Institute for Educational Statistics, National Center for Educational Statistics. The Integrated Postsecondary Education Data System. Washington (DC): http://nces.ed.gov/ipeds/. Accessed July 23, 2009.

12. The College Board. 2005 Annual Survey of Colleges. New York (NY): http://professionals.collegeboard.com/higher-ed/recruitment/annual-survey. Accessed July 23, 2009

13. American College Testing Program (ACT). Understanding Estimated Relationship: Estimating Score Conversions for ACT Composite and SAT CR+M+W Scores. ACT National Office, Iowa City (IA): http://www.act.org/aap/concordance/index.html. Accessed July 23, 2009

14. American Association of Medical Colleges, Washington (DC): http://www.aamc.org/medicalschools.htm. Accessed July 23,, 2009.

15. U.S. Department of Health and Human Services, National Institutes of Health, Research Portfolio Online Reporting Tool (RePort). Bethesda (MD): http://report.nih.gov/reportmap.aspx. Accessed July 23, 2009.

16. Accreditation Council for Graduate Medical Education, List of ACGME accredited programs and sponsoring institutions, Chicago (IL): http://www.acgme.org/adspublic/. Accessed July 23, 2009.

17. National Science Foundation, Division of Science Resources Statistics. Federal science and engineering support to universities, colleges, and nonprofit institutions: Fiscal Year 1996, NSF 98-331; Fiscal Year 2000, NSF 02-319; and Fiscal Year 2005, NSF 07-333. Washington (DC): http://www.nsf.gov/statistics/fedsupport/. Accessed July 23, 2009.

18. Association of American Medical Colleges, AAMC Data Book Medical Schools and Teaching Hospitals by the Numbers 2008, Washington (DC): http://www.aamc.org/data/databook/start.htm. Accessed July 23, 2009.

19. Bradburn NM, Sudman S. Polls and surveys: understanding what they tell us. San Francisco (CA): Jossey-Bass Inc, 1988.

20. Aaker DA, Kumar V, Day GS. Marketing Research. New York (NY): John Wiley & Sons, 1998.

21. Toto, RD. How to launch a successful career in clinical research: tips on making the most of available resources. J Invest Med 2008;56:843-846.

22. National Institutes of Health, Office of Extramural Research, Mentored clinical scientist research career development award (K-08). Bethesda (MD): http://grants2.nih.gov/grants/guide/pa-files/PA-09-042.html. Accessed Sept 3, 2009.

23. Snyderman R, Yoediono Z. Prospective health care and the role of academic medicine: lead, follow, or get out of the way. Acad Med. 2008;83:707-714.

24. Collins CD, Purohit S, Podolsky RH, Zhao HS, Schatz D, Eckenrode SE, et al. The application of genomic and proteomic technologies in predictive, preventive and personalized medicine. Vascul Pharmacol. 2006; 45:258-267.

25. Isaacs JD, Antibody engineering to develop new antirheumatic therapies. Arthritis Res Ther. 2009:19:225.

26. Plenge RM, Recent progress in rheumatoid arthritis genetics: one step towards improved patient

care. Curr Opin Rheumatol. 2009;21:262-71.

27.Deforce TK. Proteomics in rheumatology. Expert Rev Proteomics. 2008;5:755-759.

28. Moses H, Dorsey ER, Matheson DH, Their SO. Financial anatomy of biomedical research. J Am Med Assoc. 2005;294: 1333-1342.

29. Crowley WF, Sherwood L, Salber P, Scheinberg D, Slavkin H, Tilson H, et al. Clinical research in the United States at the crossroads Proposal for a novel public-private partnership to establish a national clinical research enterprise. J Am Med Assoc. 2008;291:1120-1126.

30. National Institutes of Health, Office of Extramural Research, Office of Research Information Systems, Division of Information Services. Success rates of NIH competing applications by funding institute/center, mechanism and activity code 2007-1997. Bethesda (MD): http://grants.nih.gov/grants/award/success/Success_All_2007.xls. Accessed July 23, 2009.

31. National Institutes of Health, Office of Extramural Research, Extramural Data Handbook. Average age of principal investigators, May 2008. Bethesda (MD): http://report.nih.gov/NIH_Investment/PDF_sectionwise/NIH_Extramural_DataBook_PDF/NEDB_SPECIAL_TOPIC-AVERAGE_AGE.pdf. Accessed July 23, 2009.

32. Bunton SA, Mallon WT. The continued evolution of faculty appointment and tenure policies at U.S. medical schools. Acad Med. 2007;82: 281-289.

33.Weinert CR, Billings J, Ryan R, Ingbar DH. Academic and career development of pulmonary and critical care physician-scientists. Am J Respir Crit Care Med. 2006;173:23–31.

34. Miller LE, Weiss RM. Medical education reform efforts and failures of U.S. medical schools 1870-1930. J Hist Med Allied Sci. 2008;63:348-387.

35. Getz S, Faden L. Racial disparities among clinical research investigators. Am J Theraupeutics. 2008;15:3-11.

36. Betancourt JR. Eliminating racial and ethnic disparities in health care: what is the role of academic medicine? Acad Med. 2006;81:788-792.

37. Saha S, Arbelaez JJ, Cooper LA. Patient-physician relationships and racial disparities in the quality of health care. Am J Pub Health. 2003; 93:1713-1719.

38. Cohen JJ, Gabriel BA, Terrell C. The case for diversity in the health care workforce Health affairs 2002;21:90-102.

39. Hahm J, Ommaya A, eds. Opportunities to address clinical research workforce diversity needs for 2010. Washington (DC): National Academy Press, 2006.

40. Olson, S. Fagen AP, eds. Understanding interventions that encourage minorities to pursue research careers: summary of a workshop. Washington (DC): National Academy Press, 2007.

41. Deal CL, Hooker R, Harrington T, Birnbaum N, Hogan P, Bouchery E, et al. The United States Rheumatology Workforce: supply and demand, 2005-2025. Arthritis Rheum. 2007;56:722-729

42. Brotherton SE, Etzel, SI. Graduate medical education, 2007-2008. J Am Med Assoc. 2008;300:1228-1243

43. American Medical Association, Division of Survey and Data Resources. Chicago (IL): http://www.ama-assn.org/ama/pub/about-ama/physician-data-resources/physician-masterfile.shtml

44. Dickler HB, Fang D, Heinig SJ, Johnson E, Korn D. New physician investigators receiving National Institutes of Health research project grants: a historical perspective on the ‘‘endangered species’’. J Am Med Assoc. 2007;297:2496–2501

45. Wu T, Mohan C. Proteomic toolbox for autoimmunity research. Autoimmun Rev. 2009;8:595-598.

46. Institute of Medicine: (US). Enriching the vitality of the National Institutes of Health: organizational change meet new challenges. Washington (DC): National Academy Press, 2003.

47. Kotchen, TA, Lindquist T, Malik K. Ehrenfeld E. NIH peer review of grant applications for clinical research. J Am Med Assoc. 2004;291:836-843.

48. Campbell, EA. The future of funding in academic medicine. N Engl J Med. 2009;360:1482-1483.

49. Zerhouni E. The NIH roadmap. Science. 2003;302:63-72.

50. Morrison, L. The CTSA's, the Congress, and the scientific method. J Invest Med. 2008;56:7-10.

Table 1. Self-identified ethnic backgrounds of rheumatologists, early in their careers, and graduates of allopathic medical schools 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 percent of responses reported by a cohort of 239 early career rheumatologists consisting of 107 women and 132 men.
† The ethnic backgrounds of U S medical school graduates was determined by estimating the mean number of individuals, within specified ethnic groups, that graduated from allopathic medical schools, each year, from1991 to 2005 (15). An average of 15,713 students 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 US medical schools (15).
§ 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 commitments to clinical service, teaching, research, and administration among workplaces where early career rheumatologists are employed.

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 the number of half-days/wk reported by respondents for each of the designated activities. The numbers in parenthesis are expressed as the percent effort within each workplace to facilitate comparisons among workplaces. Respondents were asked to specify the half days/wk devoted to each of the indicated activities during the 12 mo preceding 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 any activity that might be accomplished after normal working hours or on weekends, holidays or vacation periods. Note that the "total" half-days/wk deviates from the expected value of 10; the values were not normalized to 40 hr/wk to allow the data to reflect the actual values reported for each workplace.

†Clinical care providers refer to 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.

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

¶Includes the total time devoted to teaching of medical students, residents, and fellows.

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

Table 3. Assessment of the investigative activities pursued by rheumatologists early in their careers, and the effect of workplace and/or employer on the type of investigative work accomplished by rheumatologists.

Investigative activity pursued in past 12 mo.*	Gender		Both genders	Investigative commitment half-days/wk	Workplace and/or employer (mean %)			
	Women (mean %)	Men (mean %)	(mean %)	(mean ± SEM)	Clinical care provider†	Federal government HHS/DOD/VA‡	Pharma or biotech industry	Academic medical centers§
None	17.6	15.3	16.3	------	40.7	9.1	6.3	10.0
Basic	8.3	10.3	9.6	0.82 ± 0.15	1.9	9.1	12.5	13.7
Translational	6.3	9.7	8.3	0.50 ± 0.10	1.9	9.1	18.8	11.6
Disease-oriented	16.4	17.1	16.8	1.30 ± 0.16	9.3	22.7	18.8	19.5
Patient-oriented	32.1	31.5	31.7	3.46 ± 0.27	36.4	40.9	37.5	21.6
Population-oriented	15.7	12.0	13.6	1.12 ± 0.16	6.8	9.1	6.3	19.5
Prevention-oriented	3.1	4.2	3.7	0.31 ± 0.10	3.1	0	0	4.2

The results are based on a sample of 244 rheumatologists consisting of 113 women and 131 men. The type of investigative activities pursued by women and men did not differ ($P > 0.25$).

*Note, respondents were allowed to specify one or more of the designated activities to reflect the types of investigative work they pursued in the 12 mo preceding the survey. Investigative activities were defined 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. Excludes 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 refer 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 rheumatologists, early in their careers, for post fellowship research training and research project grants.

Type of proposal or grant award	Sources of funding available to rheumatologists						
	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, 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 the mean or the mean percent. Estimates of proposals submitted for post-fellowship training are based on a cohort of 51 applicants who produced 153 proposals from a sample of 247 rheumatologists. Estimates of proposals submitted for research project grants by PI's are based on a cohort of 38 applicants that submitted 233 proposals from a sample of 247 rheumatologists. Estimates of proposals submitted for research project grants by Co-PI's are based on a cohort of 17 applicants who submitted 86 proposals from a sample of 247 rheumatologists.
§ NA: data not available.

Table 5. The correlation between time dedicated to research and gender, years post-fellowship, and the "research intensity" of institutions involved in the pre- and post-clinical training of early career rheumatologists.

Explanatory variables*	Regression model†					
	1	2	3	4	5	6
Gender	0.01 ± 0.30	0.22 ± 0.29	0.03 ± 0.29	0.07 ± 0.29	0.01 ± 0.29	0.10 ± 0.29
Years post fellowship	-0.05 ± 0.02*	-0.06 ± 0.02*	-0.05 ± 0.02*	-0.05 ± 0.02*	-0.04 ± 0.02	-0.04 ± 0.02
Baccalaureate institution	0.034 ± 0.10***					
Medical school		0.26 ± 0.06***				
Residency program			0.23 ± 0.04***			
Fellowship program				0.28 ± 0.05***		
Summed score					0.59 ± 0.11***	
Ph.D. program						0.14 ± 0.32

*Time dedicated to research, the dependent variable, was determined from respondents reports of the number of half-days/wk devoted to research. The explanatory or independent variables included gender, years post-fellowship and the "research intensity" of institutions (estimated on a scale from 10 to 1 where 10 is best as noted in the Materials and Methods) respondents attended for their baccalaureate degree, medical degree, residency, fellowship, and Ph.D. when appropriate. A summed score was determined by adding the scores determined for baccalaureate institutions, medical schools, residency, and fellowship programs to provide an overall estimate of "research intensity."
†Each value is expressed as a regression coefficient ± standard error of the mean. The level of significance is designated, where appropriate, as: $P < 0.05$*, $P < 0.01$**, and $P < 0.001$***.

Table 6. Perceived disincentives for pursuing an investigative career among rheumatologists early in their careers.

Tested disincentive for pursuing an investigative career	Mean % *	
	Agree	Disagree
Clinical researchers are under compensated relative to colleagues who devote most of their professional activity to providing clinical services.	75.6	24.4
Faculty positions in medical schools or teaching hospitals are unattractive relative to private practice because of the expectation to obtain research grants/contracts and produce publications.	80.1	19.9
The time and intellectual energy required for a successful career as a clinical investigator is simply too burdensome compared with that required for a successful career involving clinical service.	53.9	46.1
Job security for clinical researchers in a medical school or teaching hospital is too risky compared with that of rheumatologists who focus on providing clinical service.	72.4	27.6

*Each value is expressed as the mean percent of responses provided for each question. The responses to each question are based on replies from 244 rheumatologists.

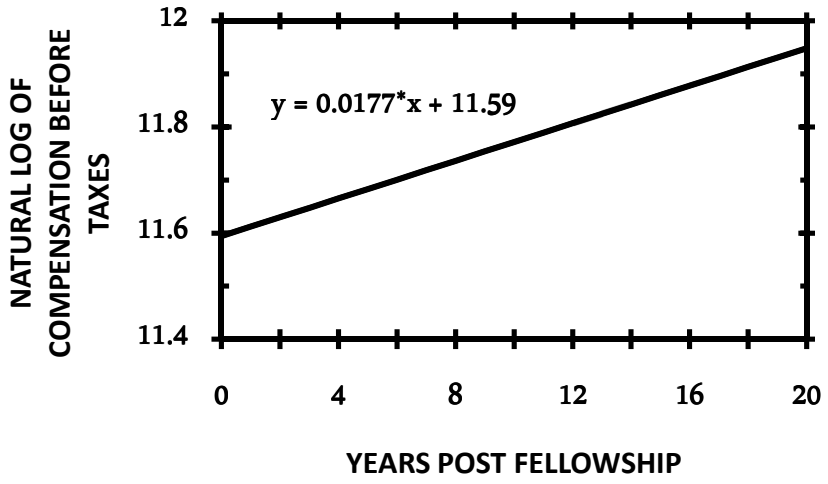

Fig. 1. The relationship between years post fellowship and the natural log of pre-tax annual earnings is described by the equation/linear function derived from a Tobit regression model. The model controlled for gender, employer, total work time/wk, half-days/wk spent on research, and for bias occasioned by missing observations. The equation predicts that the average annual pre-tax earnings of rheumatologists, early in their careers, increased by about 1.8 %/year of post fellowship experience.

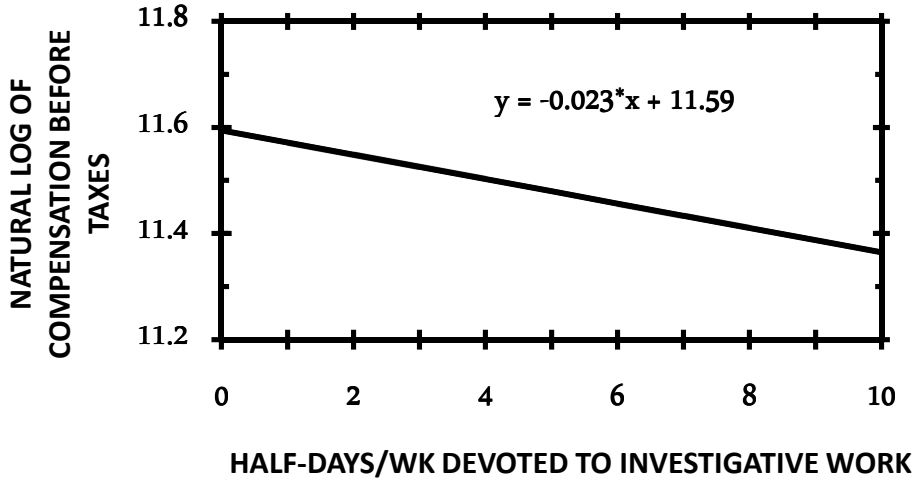

Fig. 2. The relationship between half-days/wk devoted to investigative work and the natural log of pre-tax annual earnings is described by the equation/linear function derived from a Tobit regression model. The model controlled for gender, employer, total work time/wk, half-days/wk spent on research, and for bias occasioned by missing observations. The equation, based on the cohort of rheumatologists spending 2 or more half-days/wk on investigative work, predicts that the average annual pre-tax earnings of rheumatologists, early in their careers, decreases by about 2.3% for each half day/wk devoted to research.

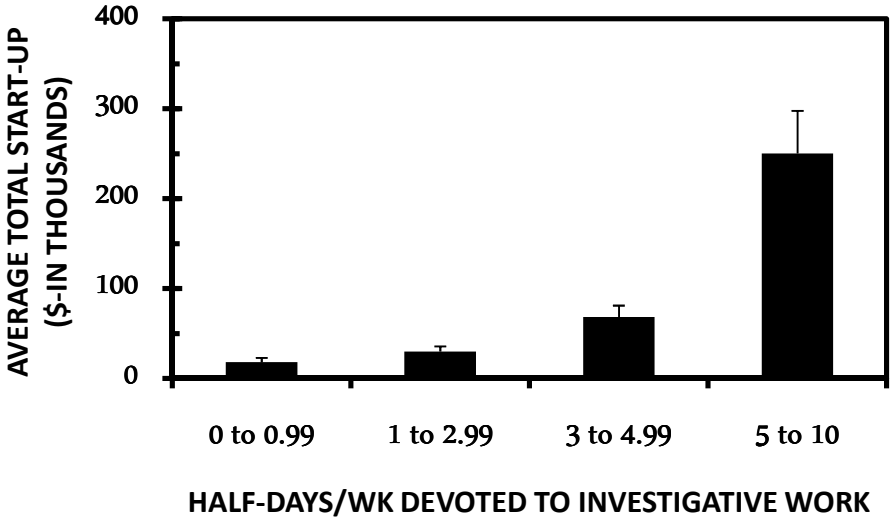

Fig. 3. Institutional investments in investigative rheumatology were estimated by considering the relationship between the number of half-days/wk devoted to research and the mean value of start-up packages (total institutional dollars for personnel, equipment, supplies, and other research expenses) provided to rheumatologists employed by academic medical centers and/or teaching hospitals. Each bar designates the mean ± standard error of the mean of dollars invested in rheumatologists early in their careers.