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Assessing the Value of Team Science:

A Study Comparing Center and Investigator-Initiated Grants

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Background: Large cross-disciplinary scientific teams are becoming increasingly prominent in the conduct of research.

Purpose: This paper reports on a quasi-experimental longitudinal study conducted to compare bibliometric indicators of scientific collaboration, productivity and impact of center-based transdisciplinary team science initiatives and traditional investigator-initiated grants in the same field.

Methods: All grants began between 1994-2004 and up to 10 years of publication data were collected for each grant. Publication information was compiled and analyzed during the spring and summer of 2010.

Results: Following an initial lag period, the transdisciplinary research center grants had higher overall publication rates than the investigator-initiated R01 grants. There were relatively uniform publication rates across the research center grants compared to dramatically dispersed publication rates among the R01 grants. On average, publications produced by the research center grants had greater numbers of co-authors but similar journal impact factors compared to publications produced by the R01 grants.

Conclusion: The lag in productivity among the transdisciplinary center grants was offset by their overall higher publication rates and average number of coauthors per publication, relative to investigator-initiated grants, over the ten year comparison period. The findings suggest that transdisciplinary center grants create benefits for both scientific productivity and collaboration.

Background

The rapid proliferation of scholarly knowledge and the increasing complexity of social and scientific problems have prompted growing investments in team science initiatives.[1-8] These initiatives typically last five to ten years and are dispersed across different departments, institutions, and geographic locations.[5, 9-11] Many of these initiatives are based on the belief that team-based research integrating the strengths of multiple disciplines may accelerate progress towards resolving complex societal and scientific problems.[12, 13] The health sciences, in particular, have embraced this approach to address pervasive public health threats such as those associated with smoking, obesity, and environmental carcinogens. [14-16]

Cross-disciplinary collaboration ranges from the least integrative form of team science, *multidisciplinary collaboration*, to the most integrative, *transdisciplinary collaboration* with *interdisciplinary collaboration* falling between those. [17, 18]. Participants in multidisciplinary and interdisciplinary collaborations remain conceptually and methodologically anchored in their respective disciplines, though some exchange of diverse perspectives occurs among research partners. Participants in transdisciplinary collaborations transcend their disciplines, engaging in a collaborative process to develop a shared conceptual framework that integrates and extends beyond the contributing disciplinary perspectives. These research initiatives create a "melting pot" for different disciplinary cultures, theoretical and methodological approaches, and technologies. However, there is limited empirical evidence concerning whether these initiatives enhance innovation, productivity, or other research outcomes. The present study explicitly compared the scientific productivity of traditional investigator-initiated research with that of center-based initiatives conducted by transdisciplinary science teams. [19]

The National Cancer Institute (NCI) within the National Institutes of Health (NIH) has supported several transdisciplinary center initiatives [20-23] over the past decade, along with related evaluation activities to better understand the impacts of these initiatives.[11, 24, 25] The first of these initiatives, the *Transdisciplinary Tobacco Research Use Centers* (TTURC), was developed because tobacco use research was becoming increasingly restricted to disciplinary silos, and there appeared to be a decline in scientific breakthroughs and related innovations in health interventions. [26] The TTURC initiative [26, 27] was launched in 1999 and renewed in 2005, ultimately supporting eight geographically dispersed centers. The grant mechanism used encouraged within- and between-center collaboration.[20,24,28]

The structure of the TTURCs was designed explicitly to promote transdisciplinary research. Each center was required to: (1) have at least three primary research subprojects, each similar in size, duration, budget, and scope to a study supported by a traditional NIH grant (R01); (2) provide career development opportunities for new and established investigators; (3) provide developmental funds for innovative pilot projects; (4) establish shared administrative, technical, statistical and other infrastructure (referred to as “cores”) to support the scientific subprojects; and (5) collaborate with other TTURCs. Centers were encouraged to collaborate with other partners such as NCI tobacco experts, community organizations and policy makers. In addition, unlike other center grant initiatives such as NIH P01s, P50s and SPORES, the TTURC initiative introduced explicit expectations related to transdisciplinary knowledge synthesis, including the development of transdisciplinary conceptual models, methodological approaches, and translational applications that would advance the science of tobacco prevention and control.

The present study examines whether the TTURC initiative produced greater scientific collaboration, productivity, and impact than traditional investigator-initiated research conducted in the same field and funding period. It had three principal research questions: (1) Are there differences in scientific collaboration, productivity, and impact between TTURC center grants and R01 grants for tobacco use research, including the volume and timing of productivity? (2) Are there within-group differences in scientific productivity among the two types of grants? (3) What factors account for differences in between- and within-group scientific productivity among the grant types?

Methods

This study used a quasi-experimental design incorporating three comparison groups. [28] The first group included the six TTURC centers with continuous funding from 1999-2009; these centers encompassed 39 distinct primary research subprojects that lasted for either 5 (N= 33) or 10 (N=6) years. The second and third components consisted of two comparison groups encompassing investigator-initiated tobacco use research grants funded through the NIH R01 grant mechanism. These groups were generated using an NIH-wide grants management database and subsequently screened by tobacco scientists to identify grants that matched the TTURC primary research subprojects on duration, timing, scope, and topical focus. The *longitudinal R01 (LR01) award comparison group* (N=21) was designed to match the 10-year duration and consistent institutional infrastructure and resources of the six TTURCs. The *stacked R01 (SR01) award comparison group* (N=39) was designed to match the duration and funding periods of the 39 TTURC subprojects.

The study incorporated bibliometric indicators of scientific productivity, collaboration, and impact as the main dependent variables. These were: number of publications, number of coauthors per publication, and journal impact factors associated with these publications. Publication data were obtained and analyzed in 2010 from two NIH databases that link grant records to publication records in MEDLINE. *Journal Citation Reports* [29] was used to obtain annual journal impact factors.

To compare TTURC subprojects to R01 grants, publications were linked to the individual TTURCs through acknowledgement of a center-based grant number and then assigned to a specific subproject using a series of algorithms as well as manual review of the annual progress reports. Publications assigned to the cores, developmental pilot projects, and multi-center collaborations were included in overall analyses of the TTURC initiative, but excluded from analyses at the subproject level because, upon manual review, they were found to be qualitatively different from publications that resulted directly from TTURC scientific subprojects and R01 grants. To account for differences in grant start dates, publications were linked to project years (e.g., year 1 of a given study). Pairwise comparison t-tests and chi-square analyses were conducted to test for between-group differences in bibliometric outcomes and selected covariates. Please see the online appendix for a more detailed description of these methods.

Results

Comparability of the TTURC and R01 Groups

Table 1 provides descriptive characteristics of the TTURC subprojects and the two groups of R01 grants, including type of research study, number of additional grants led by the PI at the time of the award, and academic rank of the PI at the time of the award. There were no significant differences in any of these covariates across groups.

All three groups had the same pattern of results for type of study and number of additional grants at the start of the award. Across the groups, the order of frequency for type of study was clinical studies (comprising the majority of the studies, at 38-64%) followed by laboratory/basic animal studies (21-31%), epidemiology/surveillance studies (15-28%), and policy research (0-9%). The majority of PIs in all three groups had one or more additional funded grants at the time of the TTURC (75%) or R01 award (LR01: 81%, SR01: 67%). Among these, most had one or two grants, followed in frequency by PIs who had no other grants at the time of the award.

Between-group differences were found in the PI's academic rank at the time of the award. In all three groups, the most common rank at the time of the award was Professor (36-54%). In the TTURC group, the second most common rank was Assistant Professor (36%), whereas in the two R01 groups the second most common rank was Associate Professor (LR01: 19%, SR01: 36%).

Differences in Scientific Productivity, Collaboration, and Impact

The top half of Figure 1 shows the total number of publications per year for each group across the ten years of TTURC funding. By year two, the LR01 group was producing at a higher rate (n

= 28 publications) than the TTURC (n = 6) or SR01 group (n = 9). However, by year three the TTURC group was producing more publications (n = 31) than both comparison groups (LR01: n = 21, SR01: n = 15), and this higher rate of productivity increased over the remaining project years. An analysis of cumulative publications for each group, by project year, shows that in earlier project years, the LR01 group produced more publications than both the TTURC and SR01 groups (Figure 1, bottom). However, by year three the TTURC group (n=39) out-produced the SR01 group (n=28), and by year five the TTURC group (n=161) out-produced the LR01 group (n=128). By year ten, the TTURC group (n=579) out-produced the SR01 group (n=251) by more than 100% and the LR01 group (n=359) by approximately 40%.

Average number of coauthors per publication and average journal impact factor per publication were assessed as indicators of collaboration and scientific impact, respectively. With the exceptions of years one and ten, the TTURC group had higher average numbers of co-authors on publications per year (*M*=6.04, SD=3.44) than both the LR01 (*M*=4.02, SD=2.48) and SR01 (*M*=4.94, SD=2.70) groups. These differences were statistically significant (TTURC vs. LR01: $t = 9.62$, $p < .0001$, $df = 936$; TTURC vs. SR01: $t = 4.48$, $p < .0001$, $df = 828$). Average journal impact factor was slightly higher in the SR01 and LR01 groups in the first two project years. However, when averaged across the full ten years, there were no statistically significant differences in average journal impact factor among the TTURC (*M*=3.82, SD=3.28), LR01 (*M*=3.78, SD=3.53) and SR01 (*M*=4.10, SD=2.64) groups. Please see the online appendix for these data.

Within- and Between-Group Differences in Productivity Among TTURC Subprojects and R01 Grants

Analyses comparing the productivity of individual TTURC subprojects to R01 grants found that, on average, the TTURC subprojects produced slightly fewer publications per project year than the LR01 group grants (0.04) and slightly more than the SR01 group grants (0.65) (Figure 2). The mean number of yearly publications across the three groups was 1.42 (TTURC: $M = 1.66$; LR01: M=1.70; SR01: $M = 1.01$). Approximately 38.5% of the TTURC subprojects produced more publications than the across-group mean compared to 38.1% of the LR01 grants and 23.1% of the SR01 grants. This difference was not statistically significant.

Low performing outliers were defined as those grants that produced zero publications across their funding period. They included one TTURC subproject (2%) and 10 SR01 grants (25%). High performing outliers were defined as subprojects or grants with publication rates between 1.5 and 3 inter-quartile range (IQR) units above the 75^{th} percentile of their group. They included two SR01 grants with 3.2 and 3.4 average publications per year (represented by the circles in Figure 2). Extremely high performing outliers were defined as subprojects or grants with publication rates more than 3 IQR units above the 75^{th} percentile of their group. They included two LR01 grants with 8.8 and 6.3 average publications per year, and two SR01 grants with 5.8 and 5.6 average publications per year (represented by the asterisks in Figure 2).

Discussion

This study demonstrated how a longitudinal quasi-experimental design, incorporating comparison groups and bibliometric indicators, can be used to evaluate the comparative outcomes of center-based and individual-investigator funding mechanisms for scientific productivity, collaboration, and impact. Analyses revealed differences in number and timing of publications, as well as co authorship patterns, between NIH-funded transdisciplinary center grants and investigator-initiated research grants in the same field, suggesting that despite an initial lag in productivity the transdisciplinary center grant funding mechanism afforded overall advantages for productivity and collaboration.

This observed lag in productivity may reflect circumstances that required substantial investments of start-up time among center grants, which are typically absent in investigator-initiated projects. These include establishing the specific infrastructure required by the TTURC initiative such as center-wide training programs and administrative cores, and mobilizing the organizational resources, processes, and policies needed to support collaborations among large teams of researchers both within and across funded centers. Examples include institutional support structures to facilitate communication, data sharing, and collaborative analyses, and cross-institutional collaboration policies.[30] Moreover, this lag may reflect the fact that the TTURCs included more junior investigators than did the two R01 groups. The presence of more junior investigators among the TTURCs also makes the overall productivity advantage of the TTURCs more striking.

Additional start-up processes that may delay publications in a transdisciplinary context include the need to develop collaborative strategies, including articulating shared goals, developing shared language for discussing scientific objectives and methods, and integrating research questions and methodological approaches from diverse fields in efforts to advance the science. Previously published data gathered during the first three years of the TTURC initiative support this hypothesis. The study documented challenges in the centers related to conflict resolution, meeting productivity, communication, project initiation, personnel turnover, and associated time burdens, which highlights potential causes of productivity lags. [11, 25]

The differences in average number of co-authors per publication between the TTURCs and R01 grants also may reflect unique features of the TTURC initiative. The center structure, center-level training opportunities, shared cores, and grantee meetings produced opportunities to create connections within and across centers, while funding agency expectations for transdisciplinary science likely encouraged collaboration within and across TTURC centers.

The lack of significant between-group differences in average journal impact factor may be a reflection of effective sampling strategies, yielding comparison groups with such similar research foci as those addressed by the TTURCs that findings were published in the same set of journals. This phenomenon may also reflect features of the tobacco field. [31] Specifically, the existence of a well established set of journals devoted to tobacco related research reduces the potential variability in impact factors for publications related to tobacco. Yet, other research suggests that collaboration may enhance scientific impact as measured by citation rates.[32] Given the limitations of journal impact factors as criteria of scientific impact, future research would benefit from additional methods for evaluating scientific productivity and influence.[33] Expert panels and science mapping techniques, including maps of citation patterns and diffusion of key concepts, are alternative methods that could be used to assess the relative impact of center grants and investigator-initiated grants.

Three notable patterns emerged from the subproject level analyses: (1) the TTURC subprojects had more consistent annual publication rates than R01 grants; (2) average annual productivity in both R01 groups was influenced heavily by high performing outliers; and (3) ten five-year R01 grants produced zero publications during the study period. Plausible explanations for more consistent annual publication rates among the TTURC subprojects include: (1) The additional levels of expectations, oversight, and visibility created by the center structure, (2) The requirement to present research progress and findings at semi-annual grantee meetings, (3) A formal mid-course review by the funding agency, and (4) Site visits by funding agency program staff and advisory committee members. The average number of annual publications in the LR01 group decreased from 1.70 to 1.09 when two extremely high performing R01 grants with the same PI were removed from the sample An important direction for future research is to identify investigator-level and institutional-level factors that account for variations in productivity among grants, especially R01s .

Notably, 25% (N=10) of the SR01 group grants – all five-year R01s -- produced zero publications over the study period, while this was the case in only one TTURC subproject, and in no LR01s. There are several possible explanations for this pattern. First, like the TTURCs, the LR01 group grants may have been supported by infrastructure and resources that were established over ten years of consecutive funding. For instance, the TTURC infrastructure (e.g., dedicated face-to-face cross-center meetings =, administrative cores), likely increased the coordination mechanisms used to facilitate collaboration, which may have lead to a greater number of papers.[34, 35] This hypothesis is also supported by the fact that the LR01s outpaced the SR01s in project years 6 through 10 (Figure 1). Another possible explanation is that peer reviewers tend to score renewal applications higher when there is evidence of productivity (e.g., publications) during the first five years of the project. The LR01 group may include grants that demonstrated high productivity.. This hypothesis is supported by the fact that the LR01 group outpaced the SR01 group (comprised primarily of five-year R01s) in cumulative publications through project year 5. Competing renewals are known to produce more papers than newly funded research.[36] Multiple methods to gauge scientific productivity would help offset limitations inherent in these bibliometric assessments, including their tendency to underrepresent productivity when investigators neglect to cite their grant numbers, resulting in the omission of relevant publications from MEDLINE and other automated data bases. It will be important for future research to capture additional forms of productivity that are not reflected in publication counts. In addition, mixed method approaches to measurement and evaluation are needed.

These findings are relevant to the design of future team science grants, including but not limited to center grants, as well as R01 grants. Funding agencies may be able to enhance support for collaboration in future team science grant initiatives by including requirements for collaboration as well as guidelines and technical assistance to implement best practices for successful collaboration. They could also provide initiative-level infrastructure to support collaboration within and across funded groups such as support for a coordinating center as in the NCI-supported Transdisciplinary Research in Energetics and Cancer (TREC) center initiative [37] Additional resources that promote effective collaboration for investigators funded either through center grants or mechanisms that support investigator-initiated research include web-based portals where investigators can access information about best practices in team science,[30, 38, 39] and cyber-infrastructures that enable cross-disciplinary networking (e.g., Research Networking Tools and Expertise Profiling Systems) and cross-project data sharing and analyses.[10, 40]

Evaluation of alternative funding durations and grant mechanisms is critically important as a basis for enhancing scientific and societal returns on future research investments. The cumulative scientific impact of particular grant initiatives can take decades to emerge. Yet, the present study demonstrates how bibliometric analyses can be used as an interim evaluation strategy for comparing alternative funding mechanisms on a variety of outcome measures. Advances in methods to evaluate the merits of different funding strategies will help to build the evidence base for crafting future funding mechanisms that maximize returns on research investments and ultimately accelerate efforts to successfully address their scientific and societal goals.

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List of Figure Titles

Table 1: Descriptive Characteristics of TTURC Subprojects and R01 Grants

Covariate	Group				
	TTURC (N=39)	LR01 (n=21)	SR01 (N=39)	X^2	**P**
Type of research study					
Policy research	1 (3%)	2 (9%)	0 (0%)		
Clinical	15 (38%)	10 (48%)	25 (64%)	9.11	NS
Laboratory/basic animal	12 (31%)	5 (24%)	8 (21%)		
Epidemiology/surveillance	11 (28%)	4 (19%)	6 (15%)		
Number of additional grants led by principal investigator at time of award					
0	10 (26%)	4 (19%)	13 (33%)		
1 or 2	19 (49%)	12 (57%)	18 (46%)	2.45	NS
3 or 4	7 (18%)	4 (19%)	7 (18%)		
5 or 6	3 (8%)	1 (5%)	1 (3%)		
Academic rank of principal investigator at time of award					
Professor	21 (54%)	10 (48%)	14 (36%)		
Associate professor	4 (10%)	4 (19%)	14 (36%)	9.51	NS
Assistant professor	10 (26%)	3 (14%)	6 (15%)		
Other	4 (10%)	4 (19%)	5 (13%)		

Figure 1: Annual and cumulative numbers of publications across comparison groups

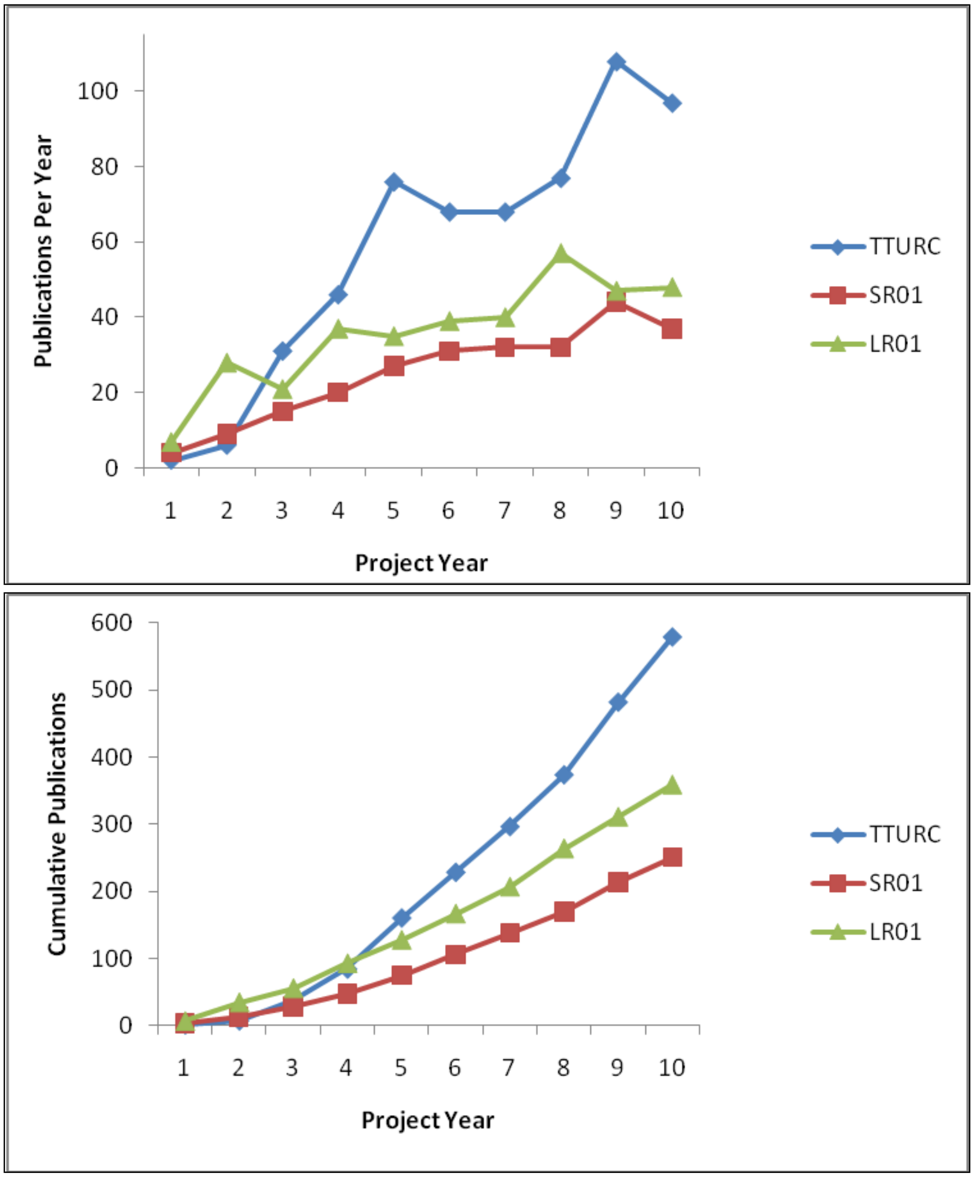
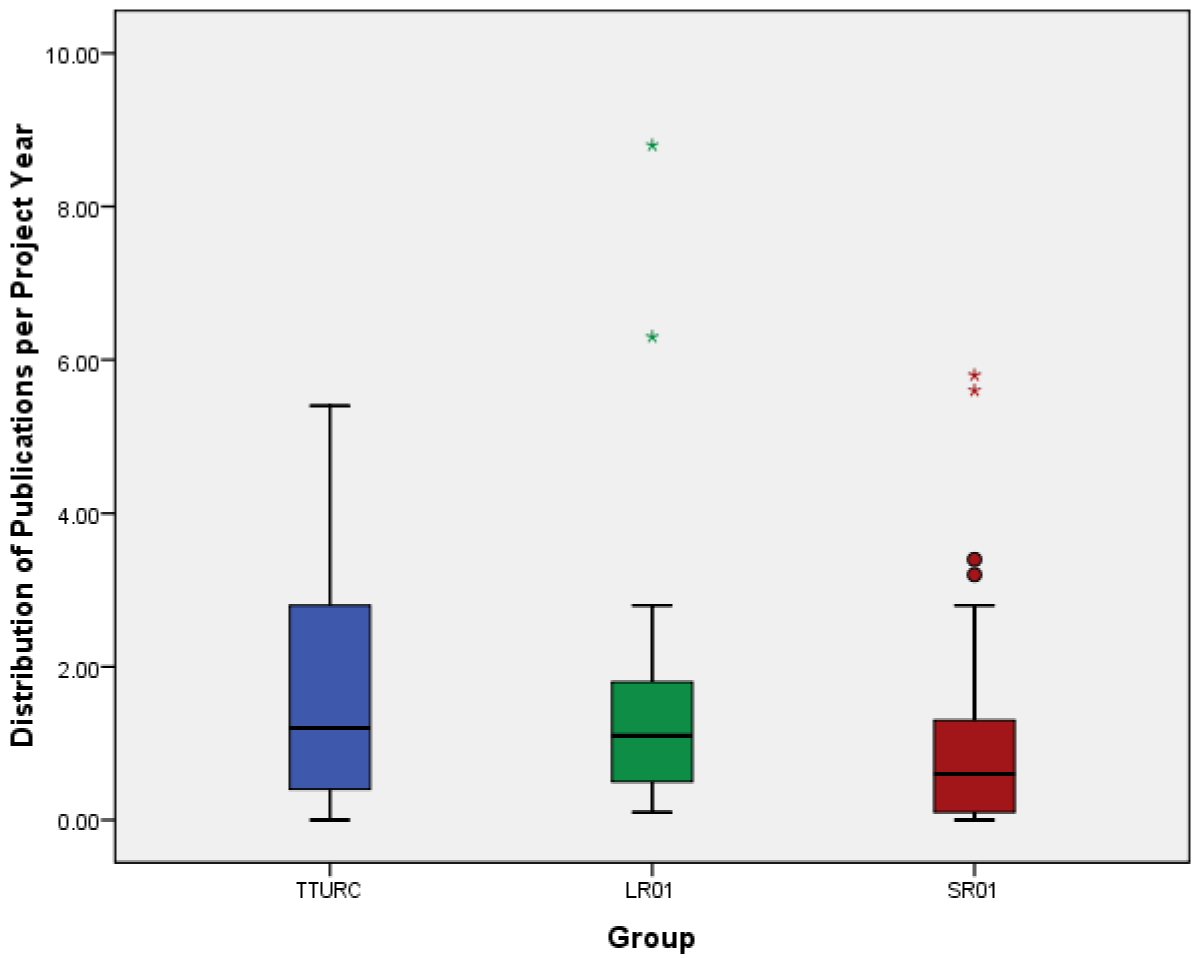


Figure 2: Box and whisker plot showing distribution of yearly publications by TTURC subprojects and R01 grants



Key:

- The top of the box represents the 75th percentile for that group while the bottom of the box represents the 25th percentile for that group.

-The black line across the center of the box represents the median number of publications for that group (TTURC=1.2; LR01 =1.1; SR01=0.6).

-The whiskers represent the highest and lowest values within the group that are not outliers

- The circles represent high performing outliers with the average number of publications per year falling between 1.5 and 3 IQR (interquartile range) units above the 75th percentile in their group.

- The asterisks represent extremely high performing outliers with the average number of publications per year falling more than 3 IQR units above the 75Th percentile in their group.

Supplementary Materials for Appendix

Materials and Methods

Sample

TTURC Centers and Sub-Projects. Seven TTURCs were funded during the first five-year funding cycle of the TTURC initiative (1999-2004). In 2004, six of the seven original centers were renewed, and one new center was funded, for another five-year funding cycle. To examine longitudinal productivity and impact, the six TTURCs continuously funded from 1999 through 2009 were included..

R01 Grant Comparison Groups. Two comparison groups of investigator-initiated tobacco use research grants funded through the NIH R01 grant mechanism were generated.. A preliminary pool of candidate R01 grants was created using a combination of text-based matching and a keyword search method for R01 grants extracted from IMPACII (Information for Management, Planning, Analysis, and Coordination II), an NIH-wide grants management database. The initial search yielded a group of 458 candidate R01 grants., which was subsequently screened by tobacco scientists to identify grants that matched the duration, timing, scope, and topical focus of the TTURC subprojects.

This process yielded two comparison groups. The *longitudinal R01 (LR01) award group* (N=21) was designed to match the 10-year duration and consistent institutional infrastructure and resources of the six continuously funded TTURCs (1999- 2009). Additionally, to minimize historical factors that could influence the outcomes of interest, the group was matched to the

TTURC funding period . This group was comprised of R01 grants funded for ten years, with at least 9 of these 10 years falling between 1999 and 2009.

The *stacked R01 (SR01) award group* (N=39) was designed to match the duration and funding periods of the 39 primary research subprojects undertaken at the six TTURCs. s. The majority (N=33) of TTURC subprojects were conceptualized and designed as five-year studies and carried out during a single TTURC funding cycle. A small number of these subprojects (N=6), however, were sustained across the two funding cycles. The SR01 comparison group was comprised of 39 R01 grants that approximated the beginning and end dates of these 39 sub-projects.

<u>Extraction of Publication Data</u>

Publication data and information needed to link publications to associated grants were extracted from multiple databases. Publications associated with the TTURC and R01 grants were identified using an automated process applied to two NIH systems that link project records from IMPAC II to publication records in MEDLINE, the National Library of Medicine's bibliographic database. These two systems, called SPIRES (Scientific Publication Information Retrieval System) and eSPA (electronic Scientific Portfolio Assistant), provide detailed information about publications that acknowledge NIH grant support. To check for accuracy, publication data gathered through this automated process were compared to publication data from a random selection of annual progress reports for the TTURC and R01 grants. In addition, whenever the automated process identified zero publications for a grant, this information was verified in the related progress reports. Annual progress reports are mandatory and submitted by researchers who receive NIH grants; they include documentation of annual publications directly related to the grant. To obtain annual journal impact factors for the identified publications, we used *Journal Citation Reports* [29].

Assigning TTURC Publications to Subprojects

For a subset of analysis, productivity was compared at the project level and therefore comparisons of TTURC subprojects with R01 grants were made (in contrast to comparisons of the overall productivity of each group). Since publications produced by each TTURC center acknowledged a common center-based grant number, a combination of data extraction strategies using both the automated bibliometric data bases described above (i.e. SPIRES and eSPA) as well as manual reviews of grant project reports was used to assign publications to each of the TTURC subprojects. Three criteria were used to make initial assignments: (1) the subproject had to be in the TTURC center associated with the grant number acknowledged in the publication; (2) the subproject had to have started before a given paper was published (i.e., subprojects unique to the second TTURC funding cycle could not be assigned to papers published before that funding cycle began); and (3) the publication had to include the subproject PI as an author. For papers that were unassigned after this process, author lists were then compared to key personnel lists obtained from annual progress reports. Each candidate subproject received a score based on the number of personnel names that matched publication authors. Personnel names associated with multiple subprojects received less weight than names that were associated with single subprojects. Using these criteria, 372 of 548 publications could be assigned to one subproject unambiguously.

The remaining 176 publications were manually reviewed by Ph.D.-level tobacco use research experts and assigned to subprojects based on publication information included in the annual progress reports and a topical match between the subproject and the publication. Eighteen of these publications were assigned to subprojects, but most (N=145) were assigned to a center's core or developmental pilot project (N=145), and 13 were assigned to a "multi-center" project category that reflected collaborative work among the TTURCs. Based on manual reviews, these multi-center publications were attributed to core activities.

Publications assigned to cores, developmental pilot projects, and the multi-center category were included in our analyses of the overall productivity of the TTURCs, but excluded from analyses that examined productivity at the subproject level because they were thought to be qualitatively different from publications that resulted directly from scientific subprojects and R01 grants. This rule was adopted both to maximize comparability of the research publications produced by TTURCs and R01 grants, and to ensure that the assessment of productivity differences between the two groups did not confer unfair advantage to the TTURCs.

Measures

Bibliometric Indicators of Collaboration, Productivity and Impact

Several bibliometric indicators were used to assess scientific collaboration, productivity, and impact of the TTURCs and R01 grants, including average number of authors per publication per year, total number of publications per year, total number of cumulative publications, and average journal impact factor per year. To compare productivity among groups, differences in funding duration were controlled for by calculating the average number of publications per project year.

As described above, TTURC publications assigned to the cores, developmental pilot projects, and multi-center project category were excluded from comparisons at this level.

Covariates

Information was extracted from IMPAC II or obtained from manual reviews of grant applications to assess potential covariates , including the PI's academic rank at the time of the award (Professor, Associate Professor, Assistant Professor, Other); number of additional grants led by the PI at the time of award (0, 1-2, 3-4, 5-6); and type of research study (clinical study, laboratory/basic animal study, epidemiology/surveillance study, or policy research). Type of research study was assigned by Ph.D. level program staff based on manual review of the study abstract provided in the grant application.

Data Analyses

In order to create comparison groups with sufficient numbers of matched grants, the start dates for the grants included in this study varied. For instance, the first round of TTURCs started in 1999, whereas the R01 comparison grants started between 1998 and 2001. Publications were therefore linked to a "project year" for each grant (e.g., year 1 of a given study) in order to make comparisons across studies. Significance testing for overall differences on bibliometric outcomes between TTURC and R01 groups was conducted in SPSS, using a series of pairwise comparison t-tests. Chi-square analyses were conducted to assess the differences between groups on selected project characteristics.

Figure 3: Average number of publication coauthors per year by group

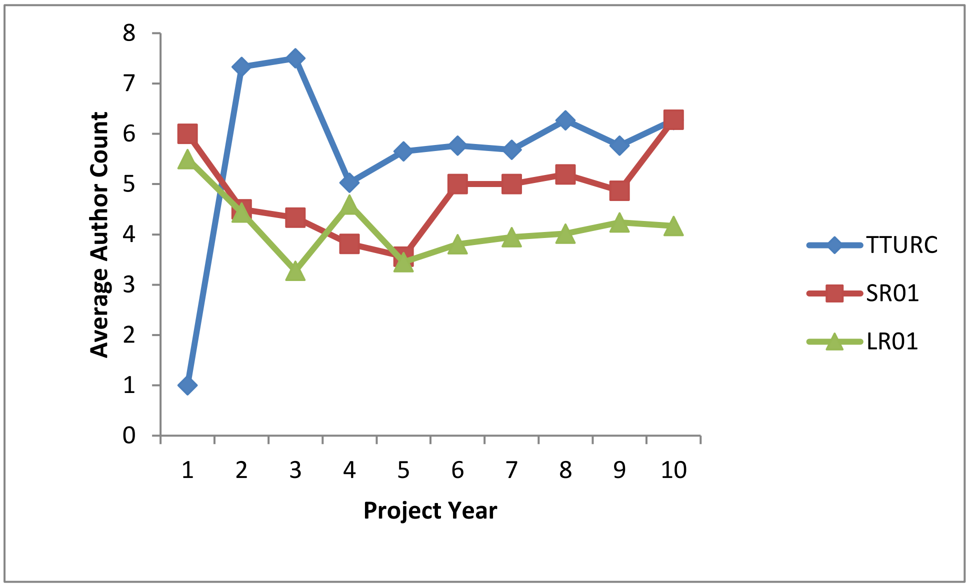


Figure 4: Average journal impact factor of publications per year by group