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QUALITY ASSESSMENT OF SCHISTOSOMIASIS LITERATURE

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Abstract

Average impact per paper, a refinement of the use of impact factor, was used to assess the quality of publications produced by a small group of sponsored researchers. The average impact per paper associated with half of the literature published by grantees has been shown to exceed those taken from the total literature at large. Moreover, this indicator appears to be stable over the five years tested. Compared with the schistosomiasis literature as a whole, the subset contributed by the grantees has consistently produced higher average impact scores. These results strongly suggest that substantial research support sustained over a significant period could foster high quality research.

INTRODUCTION

Development of quantitative indicators as an aid to science policy makers is not new. Early pioneers include such notables as Eugene Garfield, Belver Griffith, Fritz Machlup, Francis Narin, Derek de Solla Price, and Henri Small. In recent years, severe restraints on public expenditures, particularly in the U.S. and U.K., have had serious consequences on research. Numerous articles in journals such as *Scientometrics*, *Science Studies* and *Research Policy* have shown renewed interest in the development and application of objective assessment methods for monitoring and evaluating research, and for policy analysis. Indeed, Narin's analysis of technological performance based on patents and patent citations even caught the attention of the popular press [1].

Today decisions on resource allocation and establishment of program priorities depend largely on the deliberation of expert committees charged with the immediate task of discriminating among a number of applications those that are worthy of support. Although this peer judgment is an indispensable ingredient, many considerations which are non-scientific in nature should also influence each funding decision. For instance, national research priority should relate to the relative research and technological strength of the nation. Accurate research profiles of institutes and laboratories should be available to the expert committees. Objective description of the knowledge states of related fields would be another consideration in the long-range science planning of the nation. There are established quantitative methodologies which could provide these types of relevant data.

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Sir David Phillips, the former Chairman of the Advisory Board for the Research Councils in Britain, has championed the use of bibliometric techniques to produce relatively objective data to aid the science policy maker [2]. Although he asserts that the problem of science planning must rely on a balanced mix of scientific, social, political, and economic judgment, none of which are entirely objective, he believes that science policy decisions could benefit from systematic analysis of the type of data that bibliometric techniques can provide. There is an inherent appeal to objective data which could offer a more reliable indication of worth and value as an adjunct to peer review. Although such publication-based and citation-based data are limited to application in science, they are applicable to all scientific outputs and to all scientific fields. In this country, Comroe and many prominent biomedical scientists have urged the use of scientific methods to obtain data on the nature of research so that they could be applied to all aspects of biomedicine [3-7]. Even though research is widely recognized as the road to diagnoses and therapies, disappointingly little is known about : (1) the process of research, discovery and research training; (2) the critical mass necessary for major advances in science; (3) the duration needed for successful transfer from basic research in clinical applications; (4) the complex interplay between a sudden influx of funding to a subject area; (5) the process of knowledge dissimination. Obviously this list is not limited to biomedicine. There is also a critical need to develop better research performance indicators, and to understand the dynamics of scientific growth.

Controversies on bibliometric and scientometric data still remain. Most agree that publication- and citation-based measures cannot capture the full range of outcomes and benefits from research. Intangibles such as the creation of an intellectual climate at the research site, the provision of educational opportunities for one's colleagues and students, and new techniques developed and gained are but some of the many outcomes of quality research. These are not reflected in quantitative data. Criticisms have been leveled at bibliometric techniques as analytic methods. Some believe that its complexities are beyond the skills of many policy-makers [2]. Others are convinced that an abundance of data only confuses the central issue of funding. Some also questioned the reliability and stability of such results. Such critical concerns continue to caution against the sole reliance on bibliometric data. Yet questions on the validity of using publications as a measure of research output, and using citation as an indicator of worth, do not invalidate the use of bibliometric data as a tool to assess research performance [8]. This paper reports on one aspect of a study of the impact of funding on research productivity. Specifically, a quality indicator, the average impact per paper, is tested for stability over time and for its robustness. By way of an experiment, the use of this measure as a quality indicator is shown.

JOURNAL QUALITY INDICATORS

1. *Impact factor.* Impact factor is "a measure of the frequency with which the 'average article' in a journal has been cited in a particular year" [9]. The impact factor of a given journal is the ratio of the number of times cited and the number of citable articles published. It has been developed as a refinement to the raw citation frequency count, so that the disparity between journals with many and those with few articles is minimized. By averaging the citations received for each citable item, this measure also standardizes citation frequencies of older and newer journals.

Since the appearance of the annual *Journal Citation Reports* volumes of the *Science Citation Index*, impact factors of many journals are easily obtainable. Although the 1987 publication includes impact factors for 4,332 journals, most foreign journals which tend to receive fewer citations are excluded. Secondly, journals that are not cited could not be included [9]. Moreover, since citation practice is field-specific, comparison of impact factors across fields is meaningless [10]. For example, the average impact factor of physics journals is considerably higher than mathematics journals. Additionally, with respect to a subject literature or a group of articles, the use of journal impact factor may be misleading. The reason is that this measure attempts to evaluate the 'average article' in a journal without regard to the extent to which it covers a specific relevant subject. Although the impact factor of a journal gives an indication of its overall prestige, decisions relating to the procurement of a specific journal are usually linked with its coverage of a given subject which is under consideration at the moment. It is well-known that relevant articles on a given subject are distributed among many journals. Each journal does not carry the same number of articles. For example, the *Annual Review of Biochemistry*, a journal with an impact factor of 35.08 may have published an occasional paper on topic X. Even though it has the highest impact factor of the entire list covered by the *Institute for Scientific Information*, the journal is not of high utility as far as topic X is concerned. Thus a more accurate quality indicator of a journal should take into account of the extent to which it covers a given subject as well as its overall prestige as a journal.

2. *Influence Weight*. Narin and his colleagues at Computer Horizons, Inc. have developed the "influence weight" for journals in the physical and biomedical sciences [11]. This is a composite measure of the influence of a journal which incorporates citation and reference data with the number of papers it contains. It has been used to rank scientific journals. The most recent compilation of "influence weights" includes some 3,100 journals [12]. Although this measure of journal influence is more sensitive than impact factor, it is also based on the "average article" in the journal. Its coverage of journals is not nearly as comprehensive as the *Journal Citation Reports*.

3. *Average Impact Per Paper*. In this paper, the "average impact per paper" or Av I/P is proposed as an alternative. The average impact per paper represents a refined use of the impact factor. It is designed as a measure of the utility of a group of papers and is derived from taking the cumulative sum of the products of the number of relevant articles in each journal and its impact factor, and dividing the cumulative sum by the total number of articles in the group. In fact it is computed as the Mean Impact Factor as introduced by Schubert and his associates in 1985 [13]. This indicator was considered in their subsequent works as the "expected citation rate" of a group of papers [14-15]. The average impact of a group of articles is expressed as :

$$\text{Av I/P} = \frac{\sum_{1}^{i} (IF_a \times n_a)}{N}$$

where Av I/P is the average impact per paper for a given group of articles,
i is the total number of journals in the group,
IF_a is the impact factor of Journal a,
n_a is the number of relevant articles in Journal a,
N is the total number of relevant articles published by i number of journals.

As a result, this measure incorporates the prestige element of the journal by its impact factor weighted with the number of articles under consideration. Suppose one wishes to compare the "impact" or "utility" of papers in the various zones of a Bradford distribution. One may simply compute the average impact factor per paper for each zone. This allows for comparison of the average impact per paper in two groups of articles ranked by journal productivity.

AN EXPERIMENT

Schistosomiasis is one of the six great neglected diseases named by the World Health Organization. It is indeed a major disease of the developing world. Its literature has been intensely studied. Several bibliometric analyses have been reported [16-18]. Over a period of 17 years, well over 74 million dollars have been awarded to support the research of various aspects of the disease. The main focus of this project is to study the effects of research funding, that is, to analyze the relationship between funding on the one hand, and research productivity and research quality on the other. The critical consideration is whether quality research work is generated as a result of funding.

The published paper is taken as a typical outcome of scientific research [2,19]. It follows that the quality of the journal which published the reported work may offer clues on the quality and impact of the piece of research. This paper reports on the use of the average impact per paper as an indicator of utility and impact of the works published by sponsored researchers.

Schistosomiasis research has been a major focus of the National Institute of Health, the World Health Organization, the Edna McConnell Clark Foundation and the Rockefeller Foundation. Data from these four funding agencies have been collected. The names of grantees, project titles, years of award, and award levels were made available to the research team. A total of 351 individuals have been identified as having received at least one award during the period 1970 through 1986.

In consultation with the searcher who helped to update the original comprehensive *World's Literature on Schistosomiasis*, a broad search strategy was formulated for the subject for the highest possible recall without undue loss of precision [20]. Using MEDLINE as the most comprehensive source of biomedical database, the entire subject literature of schistosomiasis was captured as an electronic file. A total of 8,118 unique bibliographic citations are distributed over twenty years, from 1967 through 1986. From this total literature file, a subset of literature authored by at least one grantee was isolated. This is the grantee literature file which totalled 2,971 unique bibliographic citations.

Figure 1 shows the relationship between the two data files. The grantee file is approximately 1/3 the size of the total literature file. Except for the years before 1972, this ratio appears to be consistent in every year continuously for a 15 year period. An average of 34 percent of the literature is produced annually by the 351 grantees. Further analysis shows that there is a total of 9,916 unique authors associated with the total literature. Obviously while the average productivity of the schistosomiasis authors is 0.82 paper, an average of 8.46 papers has been produced by the grantees. A concentration of productivity on a few individuals is clear.

I. AVERAGE IMPACT PER PAPER

Two journal productivity distributions were derived from the two data files. The total schistosomiasis literature consists of 8,118 publications, 8,079 of which appeared in 938 journal titles. Similarly, 285 journals are responsible for the 2,951 articles authored by grantees. Both lists follow the skewed Bradfordian distribution. Three percent or 29 journals are responsible for half of the total literature. Twelve and a half percent of the 938 journals produced 3/4 of the literature. Similarly, 3.5 % or a more 10 journals were used to publish the top half of the grantee literature, and the top 15 journals were among the most productive journals in schistosomiasis at large. It is not surprising to find a few journals more specifically devoted to this subject. Although the average number of papers per journal is higher for the subset of

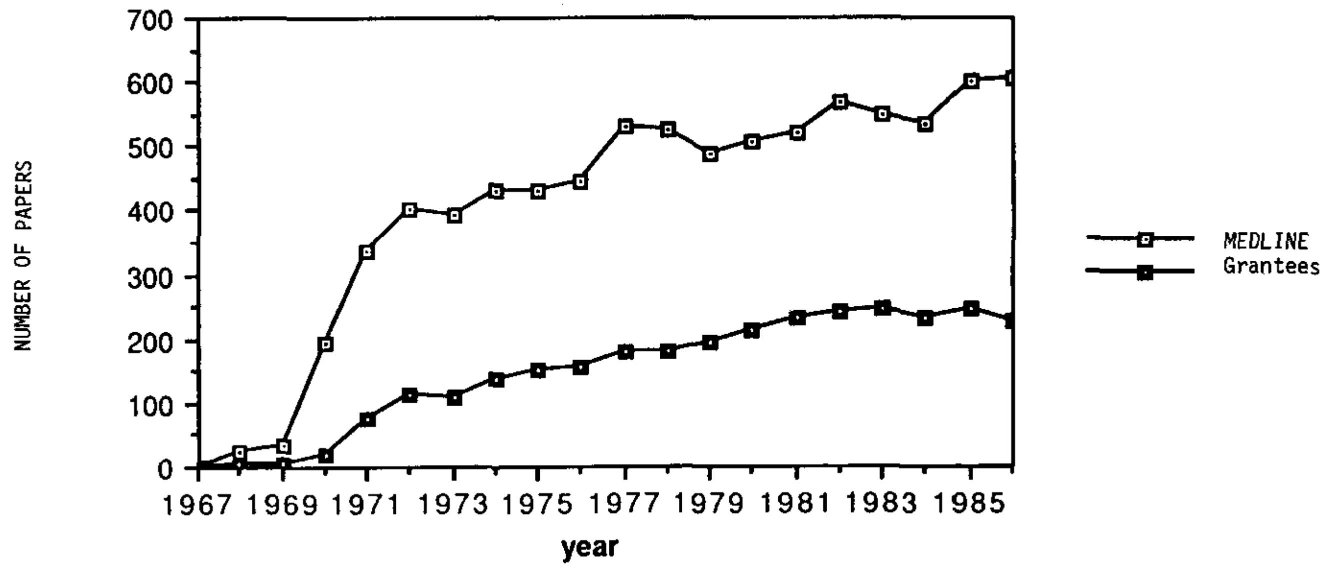

Fig.1 : Annual Publication of Schistosomiasis Literature vs
Those Contributions by Grantees

grantee literature, no direct indication of quality of the literature associated with the grantees is shown. This paper presents several tests to support the hypothesis that the average impact per paper of the group of publications produced by the grantees is higher than the average impact per paper of the total schistosomiasis literature.

1. Using half of the total literature file as the basis for computation

1.a. Table 1 lists the most productive journals arranged by the number of articles found in the total schistosomiasis file. The top 50 % of the schistosomiasis literature consists of 4,055 papers contributed by 29 journals. Instead of calculating the average impact per paper based on the entire 8,118 publications, the half of the literature found in the most productive journals was used in the computation. The average impact per paper was computed by summing the products of (1) the number of articles by each of the 29 journals and (2) its corresponding impact factor found in the 1987 volume of the *Journal Citation Reports*. The sum of the products is then divided by the total number of articles in the group of journals used, in this case, 4,055. This computation yields an average impact per paper of 1.16. Each of the 29 journals was checked for the number of papers contributed by at least one grantee. The fourth column of figures in Table 1 shows that there are 1,935 papers contributed by the grantees and these 29 journals produced 65 % of the grantee literature. The average impact per paper for the 65 % of the grantee literature is 1.70. Obviously this is higher than 1.16 derived from the total literature file. Similarly higher scores were obtained for the top 1/3 and 1/4 of the total literature.

1.b. Table 1 shows that even a highly productive journal such as the *Southeast Asian Journal of Tropical Medicine and Public Health* is not tracked by the *Journal Citation Reports*, presumably because it does not have a high enough overall impact factor. Within the 29 journals considered, 7 are in this category with no impact factor listed. In the above computation, each of 7 journals was assumed to have an impact factor value of zero. This assumption introduces a margin of error in the computation. A reasonable correction may be made by excluding the 668 articles found in the 7 journals. In other words, the sum of the products for the total literature was averaged over 4,055 in the first calculation and 3,387 was used in the second. A similar procedure was also used for the grantee literature file. This upward adjustment resulted in the average impact per paper of 1.39 and 1.78 for the total literature and the grantee literature respectively. In both comparisons, the grantee literature has produced higher scores.

2. Using half of the grantee literature file as the basis for comparison

Although the top half of the grantee literature is a proper subset of the top half of the total literature, the above computation procedures included many journals with lower ranks in the grantee file. For example in Table 1, the *Journal of Egyptian Medical Association* was ranked 13th in the total file, while it contained only 3 papers by the grantees. Thus, it was ranked towards the bottom of the grantee file. Another comparison was made using the top 1,535 articles (or 52%) from 10 journals generated by the grantees. All 10 journals with impact factors were found to have high impact factors. The average impact per paper for the top half of grantee literature was computed to be 1.97. On the other hand, 2,284 articles or only 28% of the total literature were found to come from the same 11 journals. The average impact per paper was computed to be 1.49. Hence the average impact per paper for the grantee literature is still higher than that from the total literature. Summary of the three-way comparison is shown in Table 2.

Table 1 : Average Impact Factor per paper for the top Schistosomiasis Journals (1970-1986)

Journal Titles	MEDLINE		GRANTEES		Impact Factor 1987
	rank	# of articles	rank	# of articles	
Am J Trop Med Hyg	1	507	1	340	1.86
T R Soc Trop Med Hyg	2	356	3	189	1.48
J Parasitol	3	339	2	224	0.84
Exp Parasitol	4	249	4	174	1.50
R I Med Trop Sao Paulo	5	213	14	42	0.25
Parasitology	6	185	6	151	1.74
J Immunol	7	182 (25 %)	5	157 (43 %)	6.48
Ann Trop Med Parasitol	8	180	7	97	0.68
Bull Soc Pathol Exot	9	138	24	25	0.11
SE Asian J Trop Med PH	10	128	12.5	47	*
J Helminthol	11	121	8	77	0.46
J Egypt Soc Parasitol	12	118 (33 %)	.	9 (52 %)	*
J Egypt Med Assoc	13	109	.	3	*
Z Parasitenkd	14	106	12.5	47	0.87
Egypt J Bilharz	15	103	.	9	*
J Trop Med Hyg	16	100	19	32	0.20
Int J Parasitol	17	93	10	59	1.15
Bull WHO	18	91	15	37	1.28
Chi Sheng Chung Hsueh	19	83	.	3	*
East Afr Med J	20	80	37	14	0.09
Trop Geogr Med	21	77	27	20	0.26
Mol Biochem Parasitol	22	72	9	67	3.21
Med Trop (Mars)	23	71	31	16	*
Cent Afr J Med	24	66	.	2	0.08
S Afr Med J	25	59	.	1	0.51
Acta Trop (Basel)	26	58	22	28	0.88
Ann Parasitol Hum Comp	27	58	40	13	0.39
Parasite Immunol	28	57	11	52	2.20
Yao Hsueh Hsueh Pao	29	56 (50 %)	.	0 (65 %)	*
Rev Saude Publica	30	54	.	2	*
J Infect Dis	31	52	16	35	4.36
Tropenmed Parasitol	32	51	44	12	0.84
Br Med J	33	47	48	11	2.75
Lancet	34	47	33	15	13.25
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Total journals		938		285	
Total articles		8,118		2,971	
Av IF per paper (25 %)		1.81		2.08	
Av IF per paper (33 %)		1.43		1.80	
Av IF per paper (50 %)		1.16		1.70	

* indicates that no impact factor is available
. indicates that the rank > 50

Table 2 : Comparison of average impact per paper between the Total Literature and the Grantee Literature

	Total Schistosomiasis Literature	Grantee Literature
Journals	29	29
Articles	4,055 (50%)	1,935 (65%)
Av I/P	1.16	1.70
Journals	22	22
Articles	3,387 (42%)	1,848 (62%)
Av I/P	1.39	1.78
Journals	10	10
Articles	2,284 (28%)	1,535 (52%)
Av I/P	1.49	1.97

3. Variability of impact factors

The usefulness of any indicator depends in part on its robustness. The average impact per paper is derived from the impact factors of its journals, and yet the impact factor of a given journal varies from year to year. If the variation in a significant group of journals in the subject is small, its effect on the average impact could be negligible. On the other hand, if the impact factor of the same journal swings wildly from year to year, the average impact factor per paper as an indicator of quality is clearly of limited utility.

3.a. To test the variability of the impact factors over time, the ranked order and the standard deviations of the 29 most productive journals contributing to half of the schistosomiasis literature were examined. The comparison had to be restricted to 22 journals, as impact factors for the remaining 7 journals were excluded from *Journal Citation Reports*.Impact factors were recorded from the 1987 volume of *Journal Citation Reports*.The 22 journals were listed with their 1987 impact factors. Similarly, the four preceeding volumes (1983-1986) of *Journal Citation Reports*were consulted to obtain four additional sets of impacts factors for the same journals. As a result, there were five lists of impact factors. Finally, each impact factor list was correlated with every other list resulting in a total of 10 correlations. It was found that the ten correlation coefficients lie in a narrow range from 0.944 to 0.993. Hence there is very little variation in the relative order of the impact factors of this group of journals in the last five years.

3.b. The standard deviation is a standard measure of variability. It was used to determine the variability among impact factors associated with the five consecutive years for each of the 22 journals. Results show that standard deviations for 16 of the 22 journals are less than 20 % of their corresponding means, and half of them are less than 10 %. Four of the balance of the 6 journals are in the 20-30 % range, and 50 % and 68 % are for each of the two remaining journals. Thus except for two journals, dispersion of the impact factors within the last five years appears to be small.

3.c. Since the impact factor is relatively stable, could one conclude that the average impact per paper is also fairly stable? To ensure that the differences in impact factors have insignificant effect upon the relative average impact per paper from the two groups of publications, the following tests were conducted. Using the two files containing 20 years' records, and the set of impact factors from each of the five volumes of *Journal Citation Reports*(1983-1987), the average impact per paper of the two files were computed based on the top half of the total literature file as well as based on half of the grantee file. In other words, five sets of impact factors were used. Each set was tested with three different sets of data :

(i) the top half of the total literature, compared with articles from the corresponding journals from the grantee literature, assuming zero value for those journals with no impact factor;

(ii) the same two groups of literature as the above, excluding the articles from journals with no impact factors; and

(iii) the top half of the grantee literature, compared with articles from the same journals from total literature.

In every comparison, the average impact per paper from the grantee literature exceeds that derived from the total literature. Table 3 presents a summary of the results. Regardless of the slight difference in the impact factors used from previous years, the grantee literature consistently yields higher average impact factor. All three tests above show that the variability of the values of impact factors over the previous five years did not result in any difference in terms of the relative values of the average impact per paper from the two files.

Table 3 : Test of the robustness of the Average Impact per paper

	Computations based on 50 % of the total literature 1967 - 1986				Computations based on 50 % of the grantee literature 1967 - 1986	
	all articles (journals w/o IF treated as IF=0)		only articles in journals with IF			
	literature		literature		literature	
	total	grantee	total	grantee	total	grantee
IF	Av I/P	Av I/P	Av I/P	Av I/P	Av I/P	Av I/P
1987	1.16	1.70	1.39	1.78	1.82	1.97
1986	1.12	1.60	1.34	1.68	1.69	1.98
1985	1.22	1.73	1.46	1.81	1.85	1.99
1984	1.16	1.73	1.40	1.81	1.83	2.00
1983	1.09	1.69	1.31	1.68	1.70	1.85

Based on two sets of Schistosomiasis Literature (1967-1986) and computed with IF (Impact Factors) published in 1983 through 1987.

4. Stability of the average impact per paper as a measure

4.a. An important characteristic of an indicator is its stability over time. In other words, given the results, can one expect similar results if the comparison is repeated in 2 or 3 years? To test the stability of the average impact per paper, this value was computed for the total literature and the grantee literature files at the conclusion of each of the preceeding five years. For example, literature from 1967 through 1982 was used with the 1983 impact factors taken from the 1983 volume of the *Journal Citation Reports*. Thus, in addition to the two original files, four truncated files were created from the total literature. Each was compared with its corresponding subset generated by grantees. Using the top half of the total literature as the basis for comparison, identical procedures were used. For example, the last row of data in Table 4 shows that in 1983 the average impact per paper for the total literature and the grantee literature were 1.06 and 1.52 respectively. They were computed based on the top 49 % of the total literature and 63 % of the grantee literature. If the journals with no impact factor were excluded, the values were 1.34 and 1.63 for the corresponding two files. In every case and for every period tested, the average impact per paper computed from the grantee literature file exceeds that from the total literature file. (See Table 4 columns under Av I/P). The results are stable over the five years tested.

Table 4 : Test of stability of Average Impact per paper over 5 years*

(lit. years cover)	all articles in (journals w/o Impact Factor treated as IF=0)				only articles in journals with Impact Factor					
	total literature		grantee literature		total literature		grantee literature			
	% of lit.	Av I/P	% of lit.	Av I/P	% of lit.	Av I/P	% of lit.	Av I/P	Impact mean	Factor median
1987 (67-86)	50 %	1.16	65 %	1.70	42 %	1.39	62 %	1.78	1.21	0.86
1986 (67-95)	49 %	1.08	63 %	1.56	40 %	1.31	60 %	1.64	1.14	0.75
1985 (67-84)	49 %	1.20	63 %	1.66	42 %	1.42	60 %	1.74	1.23	0.81
1984 (67-83)	50 %	1.09	63 %	1.58	39 %	1.37	59 %	1.71	1.24	0.81
1983 (67-82)	49 %	1.06	63 %	1.52	39 %	1.34	59 %	1.63	1.20	0.79

* Computation based on 50 % of the total literature for each period upto the year of the Impact Factor.

4.b. Since the means and medians of any group of data are commonly used as the most representative values for a group of data, the mean and the median impact factors of each group of journals under consideration were computed. The last two columns of Table 4 shows the means and medians of impact factors of this group of journals for each of the five years. All average values from the grantee file exceed the means and the medians. If only articles from journals with impact factor are used, the average impact values per paper from the total literature file were also higher than the means and median. However, the values computed from averaging over all articles lie between the mean and the median in every case. In other words, the average impact per paper from the total literature is less than the mean impact factor. For example, for the period 1967-1982, 26 journals produced 2,853 papers, or 49 % of the total literature. The average impact per paper was computed with this group of publications using the impact factors published in 1983. The average impact per paper was found to be 1.06 which was greater than the median but less than the mean. On the other hand, the average impact per paper computed from the corresponding grantee papers was 1.52, considerably greater than either the mean or the median (see Table 4). Additionally, using the top 50 % of the grantee literature at the basis for comparison, the average impact per paper associated with the grantee literature far exceeds that computed from the articles from the total literature in every case (Data not shown).

II. AVERAGE INFLUENCE PER PAPER

The notion of the average impact per paper may be extended to produce the "average influence per paper". Instead of using Narin's "influence weights" alone, averaging over a group of articles under consideration could produce a similar average influence weight. Thus, the last test compared the two files in terms of the average influence weight per paper using data from the list of influence weights provided by Computer Horizons, Inc. [12]. Unfortunately, many more journals from the schistosomiasis literature were excluded from the list of approximately 3,100 journals. The range of values of influence weights used varies widely. Most of the journals included have relatively low influence weights. They are mostly in the hundreds. An exception is the *Journal of Immunology* with a high influence weight of 42,221.

Similar to the previous procedure, the average influence per paper was computed by using the top half of the total literature file. This value was then compared with a subset of the grantee literature file derived from the same journals in the top half of the total literature file. Again two computations were produced, first, using all papers that appeared in journals with the assumption that those journals not in Narin's list have zero influence weight. In these cases, the comparison was made between approximately 50 % of the total literature with at least 59 % of the grantee literature. Then, it was adjusted upwards by including only those papers in journals with influence weights.

Results reveal that in every case, the average influence per paper for the top half of the grantee literature exceeds that from the total schistosomiasis literature. However, since many journals in this subject are without influence weight, the average influence weight was based on articles from relatively few journals. For example, in the 29 journals which produced the top half of the total literature, only 16 have influence weights. The average influence per paper for the grantee and the total literature were found to be 4,764 and 2,872 respectively. Similarly, averaging over the number of papers from only 16 journals produced two higher scores of 5,524 and 4,190 for the two respective sets. Nevertheless, in every comparison made, the grantee literature is associated with a higher score than the total literature.

III. TOPICAL ORIENTATION OF JOURNALS

Schistosomiasis is a parasitic disease. Traditional outlets for parasitic diseases are journals of parasitology and tropical medicine. However, one of the objectives of research funding programs has been the linking of parasitic diseases to the modern biological disciplines of immunology, biochemistry and molecular biology. In the frequency distribution of the total literature, of the 29 journals responsible for the top half of the literature, 24 are journals of parasitology on tropical medicine. The remaining five are *Experimental Parasitology*, *Journal of Immunology*, *Journal of Helminthology*, *Molecular and Biochemical Parasitology* and *Parasite Immunology*, all of which are in the tradition of modern biology. These five journals published an impressive 8 % of the total schistosomiasis literature.

On the other hand, of the 10 journals most used by the 351 grantees to publish the top half of their literature, 4 are in journals of immunology, biochemistry and molecular biology. The four journals are responsible for an amazing 16 % of the total grantee literature. In other words, the grantees as a whole have placed greater emphasis on relating the modern usage of immunology and molecular biology to this tropical disease. Since high impact factors are associated with journals of modern biology, higher average impact are linked with the grantee literature.

An additional observation is made on the schistosomiasis literature. In the 1987 volume of the *Journal Citation Reports*, only 22.4% of the total 4,332 journals cited by some 7,000 source journals had an impact factor exceeding 0.99. In terms of all scientific journals, a journal with an impact factor score of over 1,00 is considered a high impact journal. In this investigation, each computed average impact per paper score from either the total literature or the grantee literature has been greater than one. Each computation has been based on the papers from the productive journals of the literature. These journals are in fact taken from the nucleus and the first few zones of the two Bradford distributions. Although the average impact per paper between the different Bradford zones have not been examined, there is a strong implication that productive journals may be associated with quality journals. These results seem to add credence to the findings by Wallace and Bonzi that the more productive journals on a given subject also tend to be those of higher quality [21].

CONCLUSION

The analysis of a major subject literature shows that a small core of sponsored researchers has produced one-third of the literature. This impressive ratio is surprisingly consistent over a 15 year period. The group consists of 351 individuals from a total of nearly 10,000 authors in the field. They have been the recipients of research support from four granting agencies. A total sum of over 74 million dollars has been awarded in that period. Bibliometric analyses were performed to compare the subset of literature published by this group of researchers with the schistosomiasis literature at large. Results show that using the average impact per paper and the average influence per paper as two indicators of quality, the most productive half of grantee literature has produced higher scores than from the total literature on every comparison made. The average impact per paper as a measure also has been shown to be stable over the last five years. In comparing the two sets of publications, the average impact measure also appears to be robust in that impact factors from any one of the preceeding five years are able to produce similar results. Moreover, this group of funded researchers have published a substantial portion of their findings in journals which emphasize the linkage of parasitic diseases with modern biology. The conclusions that funding policies have measurable effects on the scientific journal literature seems to be supported by these data [22-23].

The remarkably consistent high performance of the grantee literature strongly suggests that research support of a major proportion sustained over a decade could foster high quality research.

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