THE CLASSIFICATION OF BIOMEDICAL JOURNALS BY RESEARCH LEVEL

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Abstract
A new method of classification of biomedical research journals into clinical or basic, or somewhere in between, is described. This is based on counting articles that have one of about 100 "clinical" title words, or one of a similar number of "basic" title words, or both. It allows over 3000 journals in the SCI and SSCI to be classified rapidly and transparently.

Introduction
It has been known for some time that, in many fields of research, papers that concern fundamental or basic research tend to have more impact than ones that concern applied work, or, in biomedicine, clinical observations (Lewison and Dawson, 1998; Lewison and Devey, 1999). This appears to be a fundamental aspect of citation behaviour, although it is often ignored when evaluations are being undertaken. However, if a bibliometric comparison is to be fair to the countries, institutions or individuals being evaluated, then account must be taken of their choice of "research level", *i.e*. whether their work tends to be basic or applied/clinical. Thus one of the parameters that needs to be determined for a group of papers, or an individual one, is its position on this scale. Similarly, it is necessary to take account of the researchers' choice of subjects because some are more fashionable than others and have a larger readership, and hence more citations (Marshakova-Shaikevich, 1996; Schwartz and Lopez Hellin, 1996; van Hooydonk *et al*., 1994).

The allocation of papers to subject areas is often simply done on the basis of the journals in which they are published. Lists of journals in many sub-fields are published by database compilers, such as the Institute for Scientific Information (ISI), which publishes the Science Citation Index (SCI). This rudimentary categorisation of papers has now effectively been superceded by methods based on analysis also of title words (Lewison, 1996; Lewison, 1999) which give a much more accurate classification, with precision and recall often exceeding 90% in some biomedical sub-fields.

However the allocation of research levels has not until now received similar attention. For many years, an approximate estimate of the research level of a paper has been available from the system devised by CHI Research Inc, whereby each journal processed for the SCI is assigned to a research level on a four-point scale (Narin *et al*., 1976; Narin and Hamilton, 1996). Journals are categorized on the basis of inspection of their contents by knowledgeable people and comparisons with journals already classified. A major factor in the choice of category is the journal's citation behaviour, since applied journals will tend to cite to basic ones, but not *vice versa*.

In the fields of biomedical research and clinical medicine, which account for about half the papers in the SCI database, these four levels are described as "clinical observation" (RL = 1), "clinical mix" (RL = 2), "clinical investigation" (RL = 3) and "basic research" (RL = 4). The CHI system has the virtue of simplicity but it has some disadvantages, too:

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- journals often contain a mix of papers and some of them will therefore effectively be mis-classified;
- journals may change their character with time so that they should perhaps be moved into a different RL category;
- the system is somewhat arbitrary and not very quantitative or reproducible.

This paper describes a new method that has been developed for application to biomedical papers and journals which aims to avoid these problems, while maintaining the essential simplicity of the CHI classification system. It is based, like the analysis of sub-fields, on the title words of papers. However, it is combined with a second classification system, whereby journals are classed as "biomedical", "fringe" (*i.e.*, partly biomedical), or "other" on the basis of the addresses of the authors and key words, expressions or contractions in those addresses, following a suggestion of de Bruin and Moed (1993). Only individual papers classed in this way as biomedical are retained for the purposes of classifying the research level of the journal using title words.

The new method not only generates a research level for the biomedical papers within each journal processed for the SCI, but also this is given as a decimal number between 1 and 4, not as a simple category. Moreover, the system can readily be applied to volumes of a journal from different years, so that any changes in its character, possibly brought about by a change of editor or of editorial policy, can be tracked. It can also be applied to journals processed for other databases, such as MedLine, for which citation data are not available. It is based on two lists of title words, given below, which are used to designate a paper as "clinical" or "basic", or "both". Thus it is reproducible by others who may wish to apply the method to non-SCI journals in which they are interested.

Method

The study began with the observation (by GP) that, since the words in the titles of papers are very useful for their classification by subject area, should they not also be of use in the provision of information on the type of research they describe? For example, papers whose titles refer to patients are almost certainly clinical and ones that refer to mice or rats are describing animal models and are therefore basic research. It is possible to create two lists of title words such that, when applied to the papers in a journal (or any other group), some will be classed as "clinical", some as "basic", some as both and some as neither. The percentages of papers in the first three groups will give a fair indication of the contents of a journal. Its biomedical content will be shown by the percentage of the papers with a biomedical word in their addresses, and its research level will be shown by the relative proportions of biomedical papers with clinical and basic words in their titles.

The lists of title words were developed as follows. The titles of articles from 16 SCI medical journals classified by CHI as "clinical observation" and from 16 biomedical journals classed as "basic research" were downloaded from the Jan – Jun 2002 CD-ROM and their component words listed in descending order of frequency of occurrence. The leading words from each list were then compared and about 100 were selected that differed substantially in both absolute numbers and ratio of frequency of occurrence. These words would supposedly have good discriminatory power and they were used to sift papers in some key journals such as *The Lancet*, *British Journal of Cancer* and the *Journal of Physiology*. It became apparent that some of the words were not working and that others were needed, especially ones that referred to animals used as experimental subjects. The final list of "clinical" words is given in Table 1, and of "basic" words in Table 2.

The new research level of the journals was calculated with respect to biomedical papers, which were selected on the basis of the words or contractions in their addresses. The biomedical filter consisted of three parts:

- generic terms embedded within the first, or institution, part of an SCI address. These were sought with each initial letter in turn, thus: A*-CANC*, B*-CLIN*, C*-DENT*, D*-HLTH, E*-HOSP*, F*-KLIN*, G*-INFIRM*, H*-MED*, I*-PHARM*,J*-VET* and all other combinations of initial letter and contraction;
- generic terms in the second or later parts of an SCI address. Some of these were ordinary biomedical words and others were special contractions used by the SCI, thus: ADDICT*, BIOCH*M, CARDIO*, DIABET*, EMERGENCY, FAMILY, GINECOL, HOP-*. Some of these words or contractions were non-English as continental European addresses are sometimes given in the original language;
- specific terms referring to laboratories or organisations (*e.g.*, pharmaceutical companies) engaged in biomedical research, thus: AMGEN*, BAYER-*, CDC, DEUTSCH-KREBS*, EMBL, FIOCRUZ*, GLAXO*, HLTH-CANADA, INSERM*.

Table 1. List of 121 “clinical” words used to identify such articles in SCI journals

abdominal	community	helicobacter	patients	stroke
adults	complications	hemodialysis	pediatric	surgery
American	controlled	hemorrhage	people	survey
anterior	coronary	hospital	peritoneal	symptoms
artery	cost	incidence	placebo	syndrome
assessment	Crohns	infant*	population	systematic
atrial	delivery	intervention	practice	term
birth	depression	ischemic	predictors	transplantation
bowel	diabetic	laparoscopic	prevalence	treated
breast	diagnosis	life	prognostic	treatment
British	diagnostic	longitudinal	prospective	trends
cardiovascular	dialysis	malignant	public	trial
care	disorder	management	quality	trials
carotid	disorders	medical	randomized	urban
case	double blind	medicine	resection	us
cases	efficacy	men	retrospective	use
cerebral	elderly	morbidity	review	venous
child	electrocardiography	mortality	risk	weight
childhood	experience	national	rural	women
children	exposure	occlusion	safety	year
chronic	findings	old	schizophrenia	years
clinical	follow	onset	sectional	
cognitive	glaucoma	outcome*	smoking	
cohort	guidelines	palliati*	socioeconomic	
colitis	health	patient	stage	

In order to determine the numbers of biomedical papers (limited to articles only) in each and every journal processed for the SCI, the three filters were run against the SCI in CD-ROM version and the bibliographic sources of 8 sets of papers fulfilling the appropriate conditions were downloaded to file. These conditions were: biomedical or all papers; combined with all papers, ones with a clinical title word, ones with a basic title word, ones with both title words. These eight files were then each processed using MS Access to yield lists of journals and the number of occurrences of each. These lists were then read across into an MS Excel file for analysis, so that each of the 3559 journals found in 2001 had its total number of papers and numbers in each of the other seven categories. It was then possible to calculate:

- percentage of biomedical address papers in a journal = % BIOM
- for biomedical papers only, (fraction classed as clinical not basic) x 1 + (fraction classed as both) x 2.5 + (fraction classed as basic) x 4 = RMcalc.

Table 2. List of 107 "basic" words used to identify such articles in SCI journals

activates	differentiation	guinea pig	monkey*	specificity
activation	distinct	hamster*	motif	spectrometry
adenovirus	DNA	helix	mouse	splicing
apoptosis	domain	histone	murine	structural
Arabidopsis	domains	homolog	mutant*	structures
assembly	*Drosophila*	IL	particle	subunit
astrocytes	*Elegans*	inhibits	phosphorylation	synthesis
binding	elements	interactions	processing	target
bovine	embryos	interleukin*	proliferation	TNF
Ca2+	encoding	intracellular	promoter	trafficking
calcium	enzymes	kappa	proteins	transcription*
channel	ER	LDL	rabbit*	transfer
characterization	*Escherichia*	localization	rat	transgenic
chromosom*	essential	loop	rats	transport
class	exchange	map	receptor*	tyrosine
cleavage	expressed	mapping	regulate*	ubiquitin
complexes	folding	mediated	regulation	*Xenopus*
conformational	frog	mediates	regulatory	yeast
conserved	functions	MHC	replication	zebrafish
core	fusion	mice	RNA*	
deficient	genes	mitochondrial	sequence*	
degradation	glial	molecules	signal*	

Of course, some of these clinical words (*e.g.*, chronic, depression, onset, quality) and some of the basic words (*e.g.*, core, fusion, map) are found in non-biomedical papers too, but often with a rather different meaning. This is why they should really only be applied to biomedical papers.

A comparison was then made between the RL values assigned by the CHI system and those calculated by the present method. This allowed the new method to be calibrated against the CHI system but it also revealed some journals whose CHI RL appeared out of line with the newly calculated value: these clearly needed further investigation.

Results

The first analysis was of the percentage of papers in each SCI journal that were biomedical on the address criterion (%BIOM). Figure 1 shows that there was a very clear tri-modal distribution, with about one third of the 3559 journals, and of the 579 616 articles in them, having 90% or more biomedical addresses; one third had less than 10% biomedical addresses, and one third were in between.

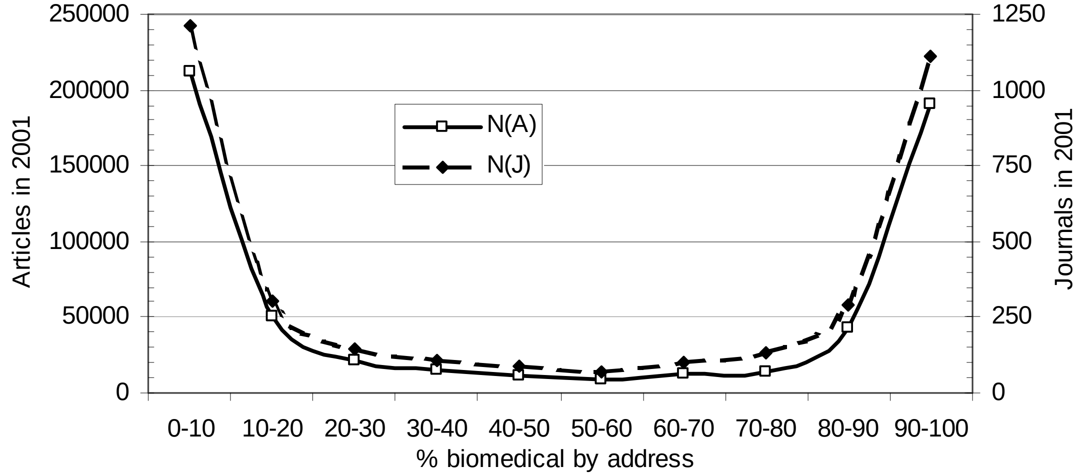

Figure 1. Distribution of journals (right scale) and articles (left scale) in the SCI, 2001, by the biomedical address content of the journals.

This was an important result for the construction of the Research Outputs Database (Dawson *et al*., 1998). This is a biomedical database of UK papers that are looked up in libraries to determine their funding sources, and it is intended to cover all biomedical journals and to include biomedical papers in other journals. It appears that the limit of complete coverage should be journals where at least 75% of papers have a biomedical address word. Thus in the 75th to 80th centiles there appeared:

> *Biomaterials, Brain and Language, Hormones and Behavior, International Journal for Parasitology, Journal of Controlled Release, Journal of Protein Chemistry, Russian Journal of Genetics, South African Medical Journal*

all of which appeared suitably biomedical. However, in the 70th to 75th centiles there were:

> *Applied Animal Behaviour Science*, *Bioelectromagnetics*, *Chemical Senses*, *Diseases of Aquatic Organisms*, *Forensic Science International*, *Journal of Natural Products*, *Photochemistry and Photobiology*

whose contents would be somewhat heterogeneous.

The classification of journals by RL can really only be carried out where there are enough papers to permit the pattern of titles to be seen. In the SCI in 2001, the biggest journal in terms of articles was the *Journal of Biological Chemistry* with 6356 papers (of which 5988 were biomedical), but there were 352 journals with no biomedical articles and a further 972 with 10 or fewer biomedical articles. For the purposes of making a comparison between the RL values assigned by CHI and those calculated by the present method, the analysis was limited to journals with at least 50 biomedical articles. Figure 2 shows that there is a fairly good overall correlation although for quite a lot of journals there is disagreement between the two systems.

The mean values of RLcalc are shown in Table 3 with the standard errors of the mean. From the point of view of allocating an RL to journals for which there is no CHI assigned level, critical RLcalc values can be taken half-way between the mean values, and so it appears that:

- journals with RLcalc <1.45 should be assigned an RL of 1 (clinical observation);
- journals with RLcalc from 1.46 to 2.20 should be assigned an RL of 2 (clinical mix);
- journals with RLcalc from 2.21 to 3.14 should be given an RL of 3 (clinical investigation),

- journals with RLcalc > 3.14 should be classed as RL = 4 (basic research).

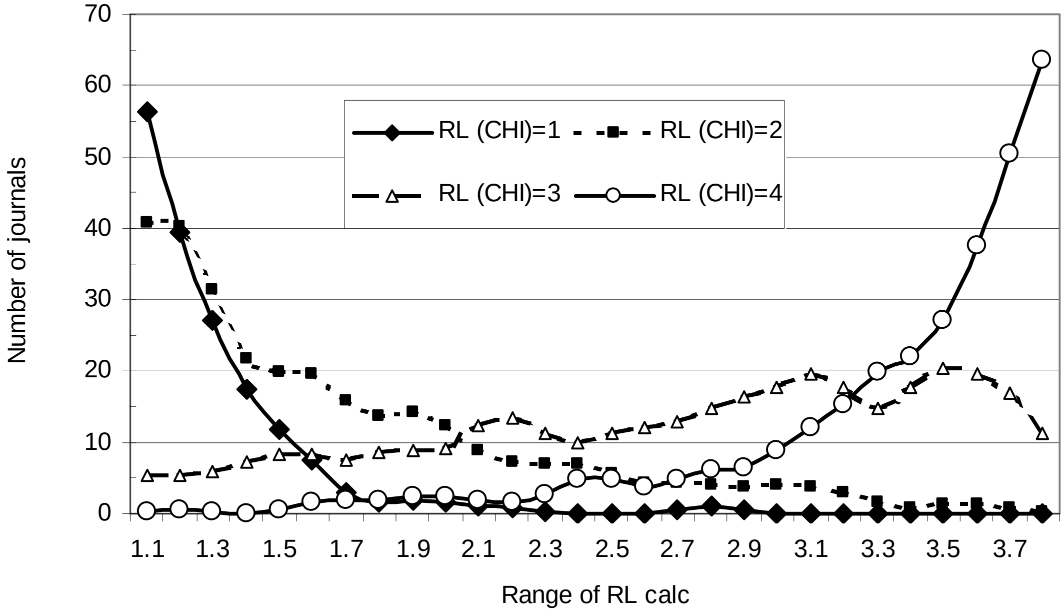

Figure 2. Numbers of journals with 50 or more biomedical papers in SCI 2001 with RL calculated by the new method in given ranges of 0.1 (three-range moving averages) for four values of RL assigned by CHI.

Table 3. Values of RLcalc for 1345 SCI journals with 50 or more biomedical articles in 2001.

RL	*N(J)*	*RL calc*	*s.e. mean*
1	238	1.26	0.017
2	333	1.67	0.033
3	354	2.76	0.041
4	372	3.52	0.026

Table 4 shows how RL values on the CHI system would be allocated to some of the 48 journals for which a CHI RL value is not available and which have 50+ articles in the SCI in 2001.

Table 4. Journals without an RL from CHI with suggested new values based on RLcalc

RL	*Journal names (RLcalc)*
1	*Health Services Research (1.00), Family Medicine (1.05), Obesity Surgery (1.08), Academic Emergency Medicine (1.17), Digestive and Liver Disease (1.25), Journal of Heart and Lung Transplantation (1.38)*
2	*Cornea (1.51), Journal of Viral Hepatitis (1.63), Oral Oncology (2.04), Melanoma Research (2.13), Pathology International (2.18)*
3	*Applied Immunohistochemistry & Molecular Morphology (2.81), Arzneimittel-Forschung-Drug Research (2.93), Journal of Human Genetics (2.98), Osteoarthritis and Cartilage 3.14)*
4	*Journal of Bioscience and Bioengineering (3.58), Journal of Industrial Microbiology & Biotechnology (3.76), Bioinformatics (3.79), Molecular Genetics and Genomics (3.96), Genes to Cells (3.97)*

The table shows that the new method works well in allocating journals to the main research levels used by the CHI system. The advantage of the method is that it is completely automatic and can easily be replicated by anyone else who uses the title words of Tables 1 and 2.

The next issue to consider was the apparent mis-allocation of some journals to RL classes. Could this be because when the journals were first classified by CHI, back in the late 1970s (Narin *et al*., 1976), they were actually rather different in character and coverage than they are now? This certainly is true of some journals, and Table 5 lists some that have changed their contents over the last 20 years so that the original category is no longer appropriate.

Table 5. Some journals that have changed their character from 1981 to 2001 in terms of research level, and which should be re-categorized.

Journal	*RL (CHI)*	*RLcalc 81*	*RLcalc 01*	*RL sugg'd*
Critical Care Medicine	1	1.20	1.72	2
Surgery	1	1.31	2.09	2
American Journal of Clinical Nutrition	3	1.85	1.30	1
International Journal of Obesity	3	1.95	1.52	2
American Journal of Hematology	3	2.05	1.51	2
Caries Research	3	2.27	1.34	1
Oncology	2	2.34	1.32	1
Circulation Research	3	2.63	3.56	4
European Journal of Cancer	3	3.00	1.70	2
Teratology	4	3.20	1.91	2

However there are others which seem to have a very different type of paper than the CHI RL would suggest, and which have always had this character. Some examples are in Table 6.

Table 6. Some journals that have not changed their character from 1981 to 2001 (or not much) in terms of research level, and which appear wrongly categorized.

Journal	*RL (CHI)*	*RLcalc 81*	*RLcalc 01*	*RL sugg'd*
American Journal of Epidemiology	2	1.04	1.07	1
Pediatrics	2	1.07	1.07	1
Health Physics	4	1.29	1.60	1 => 2
Revue de Médécine Vèterinaire	1	1.50	1.93	2
Brain and Language	4	1.50	1.81	2
European Journal of Nuclear Medicine	1	2.06	1.67	2
Annals of the NY Academy of Sciences	4	2.89	2.68	3
Archives of Toxicology	2	3.49	3.52	4
Cellular Immunology	3	3.79	3.81	4
Journal of Medicinal Chemistry	3	3.87	3.86	4

There is, as would be expected, some variation in the value of RLcalc for individual journals over time and Figure 3 shows the differences between the values calculated in 1981 and 1991, and between 1991 and 2001, for those 672 journals with 50 or more biomedical papers in 2001. There is a bell-shaped distribution, with most journals only changing their RLcalc value slightly, but a few becoming much more clinical or much more basic.

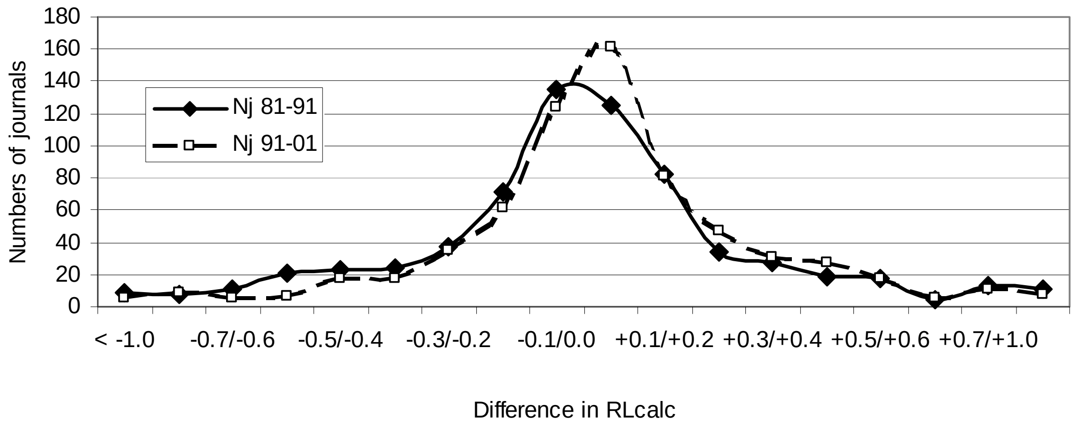

Figure 3. Numbers of biomedical journals with given changes in their calculated values of RL between 1981 and 1991, and between 1991 and 2001.

Citation performance

The question arises whether this distinction that is now being made between clinical and basic papers in a journal carries over into their citation performance. That is, do the basic papers receive more citations than the clinical ones, which would be expected on the basis that basic journals tend to be more frequently cited than clinical ones? To answer this question, six samples of 200 papers classed as clinical, mixed and basic from two journals with many of each type of paper were selected (*Cancer Research* and *Circulation*), and their five-year citation scores determined (by the ISI). Figure 4 shows the percentage distribution of citation scores for the six groups of papers, in six categories: 0-5 cites, 6-10, 11-19, 20-39, 40-79 and 80+.

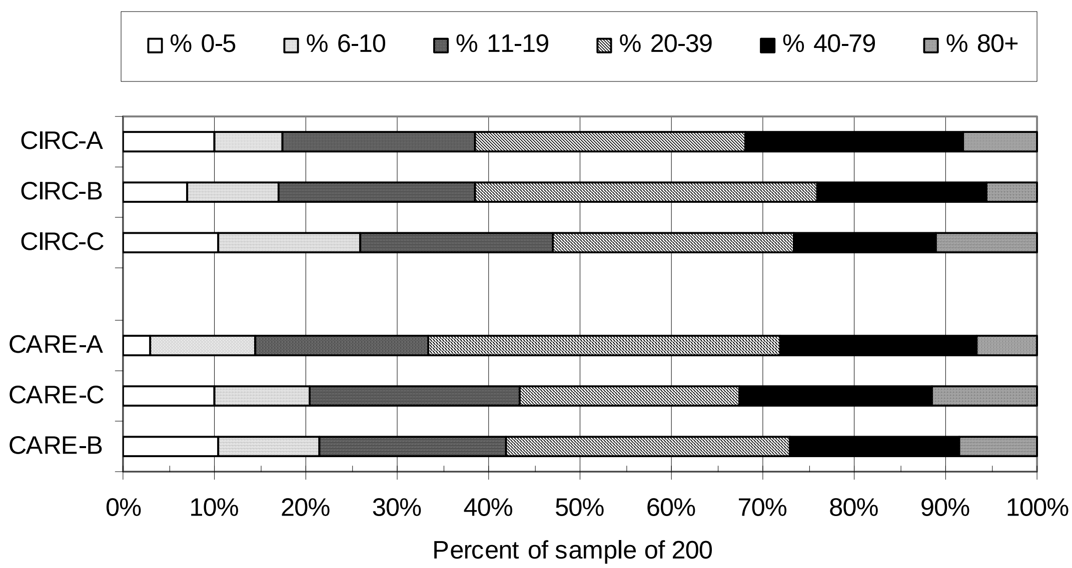

Figure 4. Percentages of papers classed as clinical (-C), basic (-B) or both (-A) from two journals *Circulation* (CIRC) and *Cancer Research* (CARE) that receive given numbers of citations in the five years following publication.

The papers with both clinical and basic words in their titles seem to be slightly more frequently cited than the others, possibly because they are of interest to two different groups of researchers. However, there does not seem to be a consistent difference between the clinical and basic papers in either journal – indeed, the ranking of the groups differs between the two journals. [The mean numbers of cites per paper for the overall sample sets of papers from each journal are 35.0 for *Cancer Research* and 33.9 for *Circulation*, compared with the means of 34.9 and 33.2 given by the *Journal Expected Citation Reports* file from the ISI. Thus the samples may be considered to be adequately representative of all the papers in the journals.] It may be concluded, therefore, that citation scores of papers depend much more on the journal in which they are published than on whether they are clinical or basic papers.

Conclusions

The new method has the limitation that it can only be applied to biomedical journals, or biomedical papers in a "mixed" journal, but many bibliometric studies, including almost all those of our group, are concerned exclusively with such research. Apart from that, it has the great advantages of transparency and reproducibility, and that it provides a continuous variable rather than a simple category, which can moreover be calculated afresh each year if needed, although a mean value for a period of years is probably sufficient. It is also very quick to calculate for all the journals in the SCI, or other database, whereas the CHI system has to be applied individually to each journal in turn.

Currently, the method has been applied to all the journals in the SCI and SSCI for the years 1991, 1993, 1995, 1997, 1999 and 2001 for routine use in bibliometric analysis. Of the 8063 journals with research articles, 2764 were classed as biomedical. Mean RLcalc values (to the nearest 0.1) were determined for 3049 journals where there were at least 20 papers over the 6 years, which could be classed as either clinical or basic. They were distributed as shown in Figure 5: there is a fairly uniform distribution except at the two ends where there are a lot of very clinical journals (over 1000 with RLcalc < 1.5) and a good number of very basic journals (over 600 with RLcalc > 3.5).

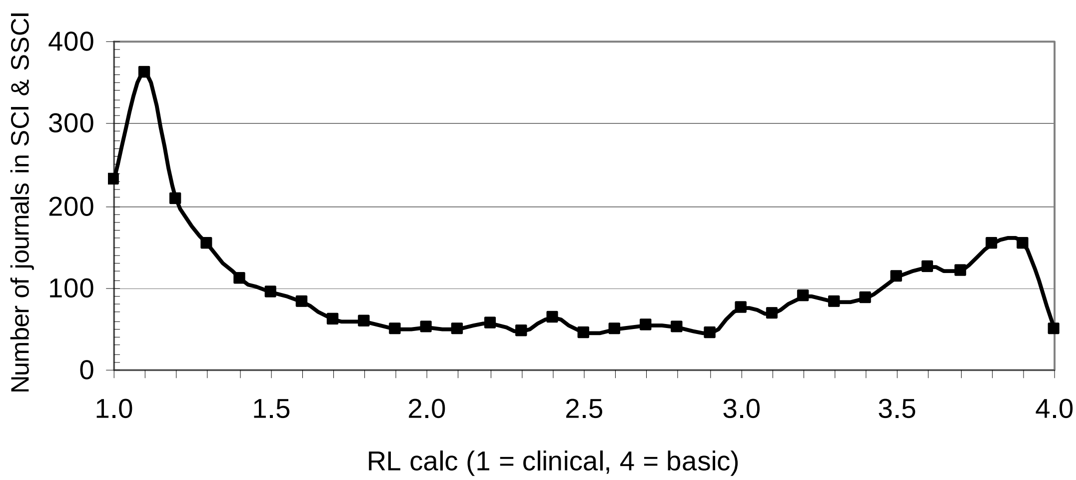

Figure 5. Numbers of journals in the SCI or SSCI from 1991 to 2001 with RLcalc values in each range of 0.1 from 1 (clinical) to 4 (basic).

We expect to use the new method of assignment of RL values in our future bibliometric work. It will provide a more precise measure of the character of each journal. However we intend also to retain the CHI values for some time in the interests of continuity, so the two systems will run in parallel.

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