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The actual citation impact of European oncological research

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ABSTRACT

This study provides an overview of the research performance of major European countries in the field Oncology, the most important journals in which they published their research articles, and the most important academic institutions publishing them. The analysis was based on Thomson Scientific's Web of Science (WoS) and calculated bibliometric indicators of publication activity and actual citation impact. Studying the time period 2000–2006, it gives an update of earlier studies, but at the same time it expands their methodologies, using a broader definition of the field, calculating indicators of actual citation impact, and analysing new and policy relevant aspects. Findings suggest that the emergence of Asian countries in the field Oncology has displaced European articles more strongly than articles from the USA; that oncologists who have published their articles in important, more general journals or in journals covering other specialties, rather than in their own specialist journals, have generated a relatively high actual citation impact; and that universities from Germany, and - to a lesser extent - those from Italy, the Netherlands, UK, and Sweden, dominate a ranking of European universities based on number of articles in oncology. The outcomes illustrate that different bibliometric methodologies may lead to different outcomes, and that outcomes should be interpreted with care.

1. Introduction

Quantitative studies of science and technology is a rapidly developing field. Its development is closely linked to a number of general tendencies in the global science system. National governments and research organisations and institutions need systematic evaluations for optimising their research allocations, re-orienting their research support, rationalising research organisations, restructuring research in particular fields, or augmenting research productivity. *Evaluative bibliometrics* is a subfield of quantitative science and technology studies, aimed at constructing indicators of research performance from a quantitative analysis of scholarly documents. Citation analysis is one of its key methodologies[1–5].

Many evaluative-bibliometric studies have focused on *oncological* research, e.g.[6–15]. This attention reflects the importance of oncological research especially in developed countries, as cancer has been, and will remain a major public health problem. Funding of oncological research both at a national and supra-national level should not only be based upon epidemiological considerations and health policy incentives, but also upon an insight into the performance of oncological research institutions and groups competing for funds.

During the past years three studies published in this journal provided an overview of the productivity and impact of oncological research in the European Union, and highlighted some of the methodological problems involved in the creation of such a bibliometric overview[7–9]. Analysing the time period 2000–2006, the study presented in this paper aims, first of all,

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to provide an update of these three earlier studies[7–9], showing results for a number of European and non-European countries.

However, at the same time, it also expands their methodologies, using a broader definition of the field, calculating indicators of actual citation impact, and analysing new and policy relevant aspects:

(1) The calculation of journal impact factors for oncology related papers in general journals and specialist journals covering other medical specialties. In this way one can compare the oncological papers in these journals with those published in specialist journals in the field.
(2) The compilation of a ranking of European universities based on their number of published articles in the field Oncology. For several years, rankings of universities have become quite popular, both among scientists and policy makers[16–18]. Therefore, the current study also presents analyses at the level of academic institutions.

Generally speaking, the methodology applied in this paper is more advanced than that applied in the three earlier studies, and provides a more complete overview. The two principal differences between these three earlier studies and the current one are the following.

Firstly, the first and third older study defined *the field Oncology* as the collection of papers in journals included in the WoS/Current Contents journal category Oncology, while the second older study applied a key words search. The classification of journals into journal categories is mainly based upon an inspection of their titles, and partly upon an analysis of citation relationships among journals. As outlined below, the current study expanded the Web of Science (WoS) journal category Oncology with oncology-related papers selected on the basis of citation relationships among individual research papers.

Secondly, the *citation based indicators* applied in the earlier studies are based on the journal impact factors of the journals in which a country has published. The study presented in this paper also calculates impact factors of the 'section' of 'oncology related' papers in more general journals and in journals covering other medical specialties. Most importantly, it provides indicators of *actual* citation impact, based on the number of times papers are cited during a certain time window specified below.

2. Materials and methods

This section describes only the main lines of the methodology applied in this paper. More details regarding this methodology can be obtained from the corresponding author. All bibliometric data were extracted from a bibliometric version of the WoS created at the Centre for Science and Technology Studies (CWTS) at Leiden University[19].

Delimitation of the field Oncology. In a first step, all papers were selected that were published in journals that are included in the WoS journal category Oncology. In a second step, oncology-related papers were selected that were published in journals not included in the WoS journal category Oncology; for instance, in general journals such as Science, Nature, The Lancet, and in journals covering other specialties. These are denoted below as *additional* oncology papers. Oncology-relatedness was measured through citation relationships[20], in the following way. From the total WoS database all papers were selected satisfying the following two criteria:

a) At least 10 per cent of documents cited in a paper were published in one of the journals in the WoS journal category Oncology.
b) They were published in journals of which at least 2 per cent of papers satisfied criterion a).

Merging the papers in the WoS journal category Oncology and the additional papers into one set, the percentage of papers in journals included in the WoS journal category Oncology accounts for about 42 per cent of the total number of Oncology papers in the combined set. This percentage is equal to that obtained by Lewison[21, p. 3141] using his filter approach based on specialist journals and title words.

The current study analysed the same *set of countries* as the earlier studies: the EU15 countries plus Norway, and the USA. The European set is denoted as EU15+. In addition, it presents outcomes for four important Asian countries: China, India, Japan and South Korea. Table 1 presents a complete list of countries included.

Article counts. In the medical scientific literature there is a variety of *document types*. Publication counts should in principle take into account peer-reviewed research papers only. Articles and reviews are normally peer reviewed and were therefore included in the counts. Letters constitute a rather heterogeneous category, including peer-reviewed short communications, but also un-refereed correspondences. It was considered more appropriate to include the peer reviewed letters than to exclude the non-peer reviewed ones. Therefore it was decided in the current study to include letters as well in the publication counts per country and university. However, in the calculation of journal impact factors (see below), citable documents include articles and reviews only. Other types of documents such as editorials were not included in the counts. The documents included in the counts will be labelled as *articles* or *papers* throughout this paper.

Journal impact factors (JIF). The impact factor of a journal J in year T is defined as follows: The number of citations received in year T by documents published in J in the years T-1 and T-2, divided by the number of citable documents published in J in the years T-1 and T-2. The impact factors presented in this paper were calculated from the bibliometric WoS database created at CWTS, and were *not* copied from Thomson Scientific's Journal Citation Reports (JCR). The methodology applied in this paper differs from that used to calculate JCR impact factors, and corrects for errors related to the definition of 'citable' documents highlighted in[22]. In the denominator of a journal's impact factor, the JCR counts as citable documents only articles and reviews, whereas in the numerator it counts citations to all documents published in a journal. For instance, for journals publishing letters all citations to letters

Table 1 – Bibliometric indicators per country

ISO Code	Country	Published articles			Relative actual citation impact (RACI)			Relative journal impact factor (RJIF)		
		Nr Articles in 2006	Rank 2006	MAGR[a] 2000–2006	RACI 2004/6	Rank 2004/6	MAGR 2000/2–2004/6	RJIF 2006	Rank 2006	MAGR 2000–2006
AT	Austria	719	10	4.8	1.0	10	1.5	1.1	5	1.7
BE	Belgium	889	8	5.2	1.3	3	1.8	1.2	1	2.4
DK	Denmark	599	11	6.8	1.4	1	0.2	1.1	3	0.1
FI	Finland	572	12	2.0	1.0	11	−8.5	1.1	9	−2.5
FR	France	3044	4	3.4	1.1	8	1.4	1.1	10	0.2
DE	Germany	4818	1	4.6	1.1	9	2.2	1.0	13	1.6
EL	Greece	776	9	11.9	0.7	16	4.1	0.7	16	1.1
IE	Ireland	246	14	12.7	0.8	15	−4.4	1.0	14	0.4
IT	Italy	3869	3	5.5	1.0	12	2.6	1.1	8	1.1
LU	Luxembourg	13	16	9.4	0.9	13	11.2	1.1	4	7.6
NL	Netherlands	1904	5	4.3	1.4	2	2.8	1.2	2	0.3
NO	Norway	534	13	8.2	1.2	5	0.9	1.0	12	1.2
PT	Portugal	187	15	13.9	0.9	14	7.6	0.9	15	−0.1
ES	Spain	1545	6	8.2	1.1	6	6.2	1.0	11	2.9
SE	Sweden	1291	7	4.4	1.1	7	2.2	1.1	7	0.1
UK	UK	4349	2	3.1	1.3	4	2.5	1.1	6	0.4
	EU15+	21,317		3.9	1.0		0.7	1.0		0.6
CN	China	2608		22.6	0.7		4.8	0.8		3.7
IN	India	842		14.3	0.5		10.7	0.6		4.8
JP	Japan	5637		0.2	0.7		0.3	0.8		0.0
KR	South Korea	1596		17.5	0.8		1.5	0.8		0.1
US	USA	22,351		5.2	1.4		−0.5	1.2		−0.5
	World Total	57,242		4.9	1.0		0.0	1.0		0.0

a MAGR: mean annual growth rate.

are included in the numerator, but the letters themselves are not included in the denominator. In a sense, these citations are 'free' and may substantially inflate a journal's JIF.

For journals *not* included in the WoS journal category Oncology, impact factors were calculated per journal for the set of papers related to Oncology, thus providing for these journals an 'oncology-related' journal impact factor (See Table 3). In addition, in the analysis by country a *relative journal impact factor (RJIF)* was calculated by dividing the average impact factor of the journals in which a country has published by the world average impact factor. A ratio of 1.0 means that the average impact factor of the journals in which a country has published is equal to the world average impact factor.

Actual citation counts. Citations were counted during a *fixed 3-year window*. For instance, for articles published in 2000, citations are counted during 2000–2002; for articles published in 2001 citations are counted during 2001–2003, etc. The last publication year for which citations can be counted during a full 3-year window is 2004 (citations counted during 2004–2006). Articles published in 2005 and 2006 cannot be followed during 3 years, therefore articles from these years were not included in the citation analysis. A *relative actual citation impact* measure (RACI) is calculated by dividing the average citation rate of a country's or institution's paper by the world citation average in the field. A ratio of 1.0 indicates that the citation impact is at world average.

Data on the number of inhabitants for *European* countries were obtained from *Eurostat*[23,24], while those for the other countries and all data on *Gross Domestic Product (GDP)* were extracted from the World Bank[25]. *Data on publishing universities* were extracted from a database created at CWTS within the framework of the ASSIST project, funded by the European Commission. Names of institutions were de-duplicated or normalised. For details of the methodology see[18].

3. Results

Data per country on the number of published papers, the relative actual citation impact (RACI) and the relative journal impact factor (RJIF) are presented in Table 1. Germany has published the largest number of papers in 2006, followed by the UK, Italy, France, the Netherlands and Spain. The total number of papers published by EU15 countries and Norway (denoted as EU15+ in Tables 1 and 2) is in 2006 very similar to that of the USA: 21,317 versus 22,351. In the numbers for EU15+, 'double counts' due to co-publications among countries in this set of European countries are avoided.

The world output in Oncology increased on average with 4.9 per cent per year. In the EU15+ set, Portugal, Greece, and Ireland show the largest mean annual growth rates (MAGR) during 2000–2006, while in the non-European set the publication output of South Korea, India and especially China increased substantially.

The relative actual citation impact (RACI) for papers published in 2004 and followed during a fixed citation window of 3 years (2004–2006) is highest for USA, Denmark, and the Netherlands, followed by Belgium and the UK. These five countries have RACI values above 1.2. Fig. 1 graphically presents RACI values for all countries included in the study. RACI for the USA is 40 per cent higher than that for EU15+

Table 2 – The number of articles per million inhabitants and per GDP

Country	Population (thousands)	Nr articles in 2006	Nr articles per million inhabitants	Total GDP (millions US $)	Nr articles per billion US $
Austria	8266	719	87.0	322,444	2.2
Belgium	10,511	889	84.6	392,001	2.3
Germany	82,438	4818	58.4	2,906,681	1.7
Denmark	5427	599	110.4	275,237	2.2
Greece	11,125	776	69.8	244,951	3.2
Spain	43,758	1545	35.3	1,223,988	1.3
Finland	5256	572	108.8	209,445	2.7
France	61,045	3044	49.9	2,230,721	1.4
Ireland	4209	246	58.4	222,650	1.1
Italy	58,752	3869	65.9	1,844,749	2.1
Luxembourg	459	13	28.3	41,382	0.3
Netherlands	16,334	1904	116.6	657,590	2.9
Norway	4640	534	115.1	310,960	1.7
Portugal	10,570	187	17.7	192,572	1.0
Sweden	9048	1291	142.7	384,927	3.4
UK	60,393	4349	72.0	2,345,015	1.9
EU 15+	392,231	21,317	54.3	13,805,313	1.5
China	1,311,798	2608	2.0	2,668,071	1.0
India	1,109,811	842	0.8	906,268	0.9
Japan	127,770	5637	44.1	4,340,133	1.3
South Korea	48,297	1596	33.3	888,024	1.8
USA	299,399	22,351	74.7	13,201,819	1.7
World	6,517,597	57,242	8.8	48,244,879	1.2

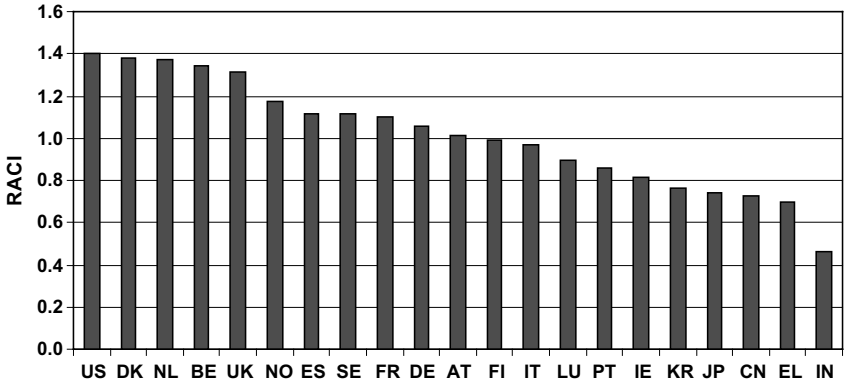

Fig. 1 – Relative actual citation impact (RACI) per country of articles published in 2004. The horizontal axis gives a country's ISO Code. For corresponding full country names see Table 1.

countries. This difference is constant over the years. Ignoring Luxembourg, that has only a very few papers per year, India, Portugal and Spain reveal the largest MAGR in this variable.

The relative journal impact factor (RJIF) shows less variation among countries than RACI, and mean annual growth rates (MAGR) tend to be lower. Comparing the RJIF and RACI rankings of European countries with one another, Norway, Spain and Germany move at least five positions downwards in the RJIF ranking, and Austria, Italy and Luxembourg at least five positions upwards compared to the RACI ranking. In other words, for the latter three countries, the actual citation impact is substantially lower than their journal impact factor. Fig. 2 gives a scatter plot of RACI and RJIF scores. In the total set of 21 countries RJIF explains about 73 per cent of the variation in RACI.

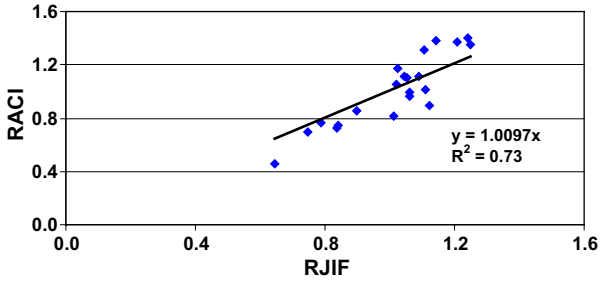

Fig. 2 – Relative journal impact factor (RJIF) versus relative actual citation impact (RACI) for European countries (year 2004/6).

For the year 2006 Table 2 gives per country the number of papers per million inhabitants, and the number of papers per GDP expressed in billion US dollars. EU15+ countries have somewhat less papers per million inhabitants than the USA (54 versus 75), and the numbers of papers per GDP are 1.5 and 1.7, respectively. In the set of European countries the Scandinavian countries and the Netherlands have the highest number of papers per inhabitant, and Portugal, Spain and Luxembourg the lowest. Sweden, Greece, the Netherlands and Finland obtained the highest number of 2006 papers per GDP, with values up or above 2.7, and Luxembourg, Portugal, Ireland and Spain the lowest.

Table 3 presents a list of the 60 journals with the highest number of papers published during the years 2004–2005, as well as their impact factors for the year 2006. As outlined in the previous section, for journals in the journal category Oncology these numbers relate to *all* 'citable' documents published in a journal, whereas for additional journals they are based on oncology-related 'citable' papers only. In other words, the impact factors of these additional journals given in Table 3 relate to their oncology 'sections'.

Table 4 further analyses the set of 60 journals presented in Table 3, and gives, for journals in the journal category Oncology, as well as for 'oncology sections' and for all papers in additional journals, statistics of the distribution of journal impact factors among journals. The table shows that in the set of 40 journals listed in Table 3 and included in the journal category Oncology, 25 per cent of journals have less than 375 articles per year and another 25 per cent more than 955 articles. The median impact factor of the 20 additional journals amounts to 3.5.

Table 4 shows that journals in the journal category Oncology tend to publish more papers than additional journals publish 'oncology related' papers, and that their impact factors tend to be lower. In addition, it shows that the impact factors of 'oncology sections' of additional journals tend to be higher than the impact factors calculated for *all* (both oncology related and non-oncology related) papers in these journals. All median values are lower than means, reflecting that distributions are skewed to the right.

Finally, Table 5 provides a list of the 50 most frequently publishing universities in EU15+ countries during the time period 2000–2004, and the relative citation impact of their papers measured during the first 3 years after publication date. The list contains 17 universities from Germany, and seven from Italy, the Netherlands and UK, four from Sweden, two from Belgium, and one from Austria, Denmark, Finland, Greece, Norway and Spain. France, Ireland, Luxembourg and Portugal are not represented in this top 50 list.

4. Discussion

Comparing the results on publication output and citation impact per country presented in Table 1 with the findings published by Ugolini and Mela[9], the following observations can be made. The five countries with the highest number of published articles in the current study are the same as those in the top five in[9]. However, in the recent study, Germany takes the first position, not only in 2006, but - according to data collected in the study but not shown in the previous section - also in 2000, while in[9] in the year 2000 it ranked number three. As indicated in Section 1, major differences exist in the methodologies applied among the two studies. Analysing and discussing the effect of each difference upon the rankings goes beyond the scope of this paper.

But one factor should be mentioned here: the Web of Science used in the current study has a wider journal coverage than the version of the Thomson/ISI databases used in[9] (Scisearch), and tends to cover more European continental journals. In fact, in the current study, and for the year 2000, Germany shows the highest increase in the number of published articles compared to the earlier study, followed by Italy and France, while UK and the Netherlands, two countries that traditionally are strongly oriented towards the Anglo-Saxon literature, reveal the lowest increase.

The mean annual increase in publication numbers of the Asian countries India (14.3 %), South Korea (17.5 %) and especially China (22.6 %) is noteworthy. The world publication output in Oncology increased during 2000–2006 on average with 4.9 per cent per year. For USA this mean annual growth rate is slightly higher (5.2 %), for EU15+ one per cent lower (3.9 %). This outcome suggests that, in the journals covered by the WoS, the emergence of the Asian countries in the field Oncology has displaced European research articles more strongly than papers from the USA.

The rankings based on relative journal impact factors (RJIF) differ substantially among the two studies. In[9], Netherlands, Finland, UK, France and Sweden are in the top five, whereas in the recent study (not including Luxembourg) these top positions are occupied by Belgium, Netherlands, Denmark, Austria and UK. It needs emphasising that the older study takes into account papers in journals included in the journal category Oncology, while the current study also counts papers in 'additional' journals, i.e. in more general journals and specialised journals covering other medical specialties.

In the analysis of relative actual citation impact, which was not carried out in[9], Denmark, the Netherlands, Belgium, UK and Norway occupy in this order the first five positions. Spain is at the sixth position. Although in the total set of countries analysed in this paper the relative actual citation impact (RACI) and the relative journal impact factor (RJIF) of a country's articles show a rather strong correlation (Pearson's R is 0.85), for several countries their position in the RACI ranking differs substantially from that occupied in the RJIF ranking. For Norway, Spain and Germany, RACI is substantially higher than RJIF (they move at least five positions upwards in the RACI ranking compared to the RJIF ranking), while for Austria, Italy and Luxembourg it is the opposite case (they move at least five positions downwards in the RACI ranking compared to that for RJIF).

These outcomes support the conclusion reached in many earlier bibliometric studies, stating that although the status of the journals in which a research group publishes as reflected in their impact factors is an aspect of research performance in its own right, journal impact factors should not be used as a measure of actual citation impact of a group's publications[26–28]. The two indicators measure distinct aspects of research performance. Rankings based on each of these

Table 3 – The 60 journals with the highest number of articles published during 2004–2005 and their impact factors for the year 2006

Journal	Nr Articles and reviews 2004–2005	Impact factor 2006[a]	Journal category (If not Oncology)	In Table 2 Ugolini et al., 2002[8]
Cancer Research	2778	7.4		Y
Clinical Cancer Research	2155	5.8		N
Oncogene	1850	6.2		Y
Journal of Clinical Oncology	1591	10.7		Y
Anticancer Research	1370	1.4		Y
International Journal of Cancer	1370	4.2		Y
British Journal of Cancer	1318	4.1		Y
Cancer	1299	4.2		Y
Journal of Biological Chemistry	1292	6.2	Biochem & Mol Biol	Y
International Journal of Radiation Oncology Biology Physics	1150	4.0		N
Gynecologic Oncology	1030	2.3		N
Blood	944	9.9	Hematology	Y
Experimental Cell Research	880	3.7		N
Oncology Reports	848	1.5		N
Biochemical and Biophysical Research Communications	826	2.9	Biochem & Mol Biol	Y
International Journal of Oncology	808	2.5		Y
Cancer Letters	778	2.9		N
Cancer Epidemiology Biomarkers & Prevention	732	4.0		N
Annals of Oncology	649	4.4		Y
European Journal of Cancer	625	3.8		Y
Bone Marrow Transplantation	617	2.2		Y
Leukemia & Lymphoma	603	1.3		Y
Carcinogenesis	533	4.9		Y
PNAS-US	503	11.1	Multidisc sci	Y
Leukemia	492	4.5		Y
Journal of Urology	488	4.0	Urol & Nephrol	N
Lung Cancer	486	3.0		N
Urology	433	2.2	Urol & Nephrol	N
Cancer Genetics and Cytogenetics	426	1.5		Y
Journal of Neuro-Oncology	402	1.7		N
Radiotherapy and Oncology	402	3.5		N
Breast Cancer Research and Treatment	401	2.9		N
Pediatric Blood & Cancer	390	1.4		N
British Journal of Haematology	388	4.1	Hematology	Y
Molecular Cancer Therapeutics	384	5.2		N
Leukemia Research	381	2.1		N
International Journal of Gynecological Cancer	376	1.4		N
Seminars In Oncology	375	3.3		N
Molecular and Cellular Biology	363	7.9	Biochem & Mol Biol	N
Cell Cycle	360	3.3	Cell Biology	N
Hepato-Gastroenterology	347	0.7	Gastroenterol & Hepatol	N
Cancer Chemotherapy and Pharmacology	346	2.2		N
Journal of Pediatric Hematology Oncology	335	1.1		N
Modern Pathology	335	3.2	Pathology	N
Ejso- Eur J Surg Oncol	319	1.8		N
Journal of The National Cancer Institute	317	12.0		N
Prostate	311	3.8	Urol & Nephrol; Endocrinol & Metabolism	N
European Journal of Gynaecological Oncology	308	0.6		N
Journal of Surgical Oncology	300	1.9		N
Bju International	297	2.3	Urol & Nephrol	N
Bioorganic & Medicinal Chemistry Letters	294	2.6	Chem, Medicinal & Organic	N
Oncology	294	2.3		N
Annals of Surgical Oncology	291	3.0		N
Stem Cells	288	6.8		N
Medical Physics	287	3.3	Radiol, Nucl Med & Med Imaging	N
Annals of The New York Academy of Sciences	286	2.5	Multiscipl Sci	N

Table 3 – (continued)

Journal	Nr Articles and reviews 2004–2005	Impact factor 2006[a]	Journal category (If not Oncology)	In Table 2 Ugolini et al., 2002[8]
Journal of Immunology	286	6.1	Immunology	Y
Journal of Medicinal Chemistry	283	4.7	Chemistry, Medicinal	N
American Journal of Surgical Pathology	280	4.2	Pathology	N
International Journal of Molecular Medicine	279	1.9	Medicine, Res & Exp	N

a For journals in the journal category Oncology these indicators relate to *all* 'citable' documents (normal articles and reviews) published in a journal, whereas for additional journals assigned to other categories they are based on oncology-related 'citable' papers only.

Table 4 – Statistics of the distribution of journal impact factors among journals presented in Table 3

Type		Nr Journals	Nr articles per year (2004–2005)				Journal Impact Factor (2006)			
			Mean	P25	Median	P75	Mean	P25	Median	P75
In journal category Oncology	All articles	40	757	375	512	955	3.6	1.8	3.0	4.3
Additional journals	Oncology related articles	20	222	143	170	230	4.3	2.5	3.5	5.4
	All articles	20	2321	694	1474	2563	3.9	2.3	3.2	5.2

should be compared with one another, and discrepancies should be underlined.

This conclusion also holds at the level of individual researchers. At this level journal impact factors and actual citation impact show correlations that are much lower than those obtained at the level of countries in the current study. For instance, a study of a sample of about 2100 senior authors from the UK revealed that the average journal impact factor of an author's publication oeuvre explains only 11 per cent of the variance in its actual citation impact[29]. It also needs emphasising that there is no empirical evidence for the claim that most prolific authors publish only in the most prestigious journals, whereas less prolific authors publish their papers in journals with a lower status. Prolific authors publish both in high impact and in lower impact journals[5, p. 104]. This underlines the importance of journals with a somewhat lower citation impact in the communication of research findings by both prolific and less prolific researchers.

Comparing the list of journals in Table 4 to that published in[8] leads to the following observations. There is a core of journals publishing papers on oncological research that is represented in both lists. Almost all of these core journals are included in the journal category Oncology. The overlap between additional journals in the two lists is much lower. It must be noted that the list presented in this paper relates to articles published during 2004–2005, and that published in[8] to documents published in 1995. Differences between the lists are therefore partly due to changes in authors' publication practices, the emergence of new research topics, and the foundation of new journals. But these differences also reflect differences in methodology: the field delimitation in[8] is based on a key word search and that in the current study on citation patterns among journals.

The analysis presented in this paper clearly illustrates how the outcomes of bibliometric analyses are dependent upon the methodologies that were applied. At first glance it may seem simple and straightforward to count publications and citations per country, and calculate indicators of publication output and impact. But any practical exercise is confronted with a number of crucial issues: what precisely is to be counted; how is it counted; in which universe is it counted; which type of indicators are calculated; and which aspects of research performance do they reflect. The outcomes presented in this paper fully underline the warning issued in[8, p. 1125] that 'different evaluation methods lead to different results, and care needs to be taken in the interpretation of these'.

The outcome that additional journals (general medical journals and specialist journals covering other specialties) contain on average less papers per year than specialist journals in the journal category Oncology is rather trivial, but the finding that their impact factors tend to be higher than those for the journals in the category Oncology, and also higher than the impact factors calculated for *all* papers in additional journals, is significant. Causality relations tend to be complex, but this result at least shows that oncologists who have published their papers in additional journals rather than in their own specialist journals, have generated a relatively high actual citation impact, compared to that of their papers in oncological specialist journals.

A possible explanation for these findings is that authors who submit a paper to a more general journal present findings that are relevant not merely to their specialist community, but to a wider scientific audience. If their paper is published in a more general journal, it is exposed to a wider reading audience than are their articles in oncological specialist journals, and therefore generates a higher citation impact. In order to further test this hypothesis, a secondary analysis should focus on the journals and subfields from which the various types on oncology papers are cited, and

Table 5 – 50 most frequently publishing European universities during 2000–2004 and their relative actual citation impact

University	Country	Nr articles 2000–2004	Relative Actual Citation Impact
Karolinska Inst Stockholm	Sweden	2391	1.05
Univ Wien	Austria	1747	0.83
Erasmus Univ Rotterdam	The Netherlands	1683	1.28
Univ Milano	Italy	1538	0.95
Ruprecht Karls Univ Heidelberg	Germany	1511	1.07
Univ Coll London	UK	1377	1.26
Ludwig Maximilians Univ Munchen	Germany	1368	0.98
Humboldt Univ Berlin	Germany	1339	1.00
Vrije Univ Amsterdam	The Netherlands	1213	1.32
Univ Helsinki	Finland	1199	1.45
Leiden Univ	The Netherlands	1188	1.25
Univ Roma Sapienza	Italy	1184	0.77
Eberhard Karls Univ Tubingen	Germany	1128	0.86
Natl & Kapodistrian Univ Athens	Greece	1127	0.56
Radboud Univ Nijmegen	The Netherlands	1080	1.09
Univ Torino	Italy	1040	1.05
Uppsala Univ	Sweden	1037	1.04
Lunds Univ	Sweden	1004	1.03
Katholieke Univ Leuven	Belgium	945	1.62
Univ Hamburg	Germany	918	1.08
Univ Utrecht	The Netherlands	905	1.28
Kobenhavns Univ	Denmark	898	1.06
Imperial Coll London	UK	892	1.50
Univ Munster	Germany	886	0.94
Univ Koln	Germany	865	0.97
Univ Bologna	Italy	847	0.85
Univ Oxford	UK	839	1.87
Univ Amsterdam	The Netherlands	833	1.20
Univ Groningen	The Netherlands	798	0.98
Univ Ulm	Germany	785	1.22
Univ Napoli Federico Ii	Italy	775	0.93
Univ Freiburg	Germany	769	1.07
Univ Padova	Italy	755	0.71
Heinrich Heine Univ Dusseldorf	Germany	753	0.96
Univ Oslo	Norway	745	0.94
Univ Leeds	UK	740	1.17
Tech Univ Munchen	Germany	724	1.06
Univ Barcelona	Spain	724	1.20
Johannes Gutenberg Univ Mainz	Germany	721	1.11
Johann Wolfgang Goethe Univ Frankfort	Germany	706	1.05
Univ Birmingham	UK	689	1.33
Univ Glasgow	UK	676	1.30
Friedrich Alexander Univ Erlangen	Germany	662	1.01
Univ Duisburg Essen	Germany	662	0.94
Univ Cambridge	UK	661	1.86
Univ Libre Bruxelles	Belgium	630	0.86
Bayerische Julius Maximilians Univ Wurzburg	Germany	630	1.14
Univ Firenze	Italy	628	0.76
Medizinische Hochschule Hannover	Germany	626	1.08
Univ Manchester	UK	625	1.06

compare across types the percentage shares of citations from oncological specialist journals and those from additional journals.

As regards the ranking of European universities presented in Table 5, it needs emphasising that the results can only be interpreted properly when one takes into account the structure of the national academic system in which it is embedded, and especially the organisation of its oncological research. In countries such as France and Spain, important centres of cancer research were founded outside the university system. The ranking in Table 5 tends to be dominated by universities from countries in which the overwhelming part of oncological research is carried out in universities (including academic hospitals). In order to generate a more complete overview, the authors of this paper plan to carry out a follow-up study in which research institutes and hospitals will be included in the ranking.

The need for policy makers and the wider public to obtain insight into the scholarly quality of research activities in universities is legitimate, but scholarly research quality is not as

straightforwardly measured and ranked as performance in many other societal domains. Rankings are in a sense one-dimensional: entities are ordered by descending score on one particular statistic, even though such a statistic may express the outcomes of a series of weighted parameters. They disregard relationships among entities, particularly how the performance of one entity depends upon that of others[30].

Conflict of interest statement

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