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REVIEW

BIBLIOGRAPHIC OUTPUT OF THE INSTITUTE FOR MEDICAL RESEARCH AND OCCUPATIONAL HEALTH IN ZAGREB BETWEEN 1994 AND 1998

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This paper brings a classification of the bibliographic output of the Institute for Medical Research and Occupational Health over the period 1994–1998 into fourteen main categories according to the type of publication and its coverage in different bibliographic databases. The academic staff was classified according to scientific fields in which they received the bachelor's degree and in which they were appointed into a scientific grade. The authors compared the Institute's scientific performance in the last five years to previous periods and with achievements of similar institutions in Croatia. Regardless of a large decrease in the Institute's personnel, the number of scientists with a Ph.D. degree remained unaltered. The ratio between published papers covered by *Current Contents* and the number of scientists holding a Ph.D. degree slightly dropped, while the ratio between the publication of conference abstracts and Ph.D.s doubled.

Key words:
bibliographic analysis, co-authorship, impact factor, publication counts, scientific fields, type of publication

Institute for Medical Research and Occupational Health (hereinafter the Institute) has a long tradition in following up the bibliographic output of its scientific staff over the past 50 years. Reports on its activities, including the bibliography, have regularly been published every year in the *Archives of Industrial Hygiene and Toxicology*. The scientific performance of the Institute was evaluated by the Institute's researchers (1–5). The analyses covered periods 1948–77 (1), 1968–77 (2), 1968–83 (3), 1988–93 (4), and 1988–97 (5). In addition, the Institute's performance was analysed in papers evaluating the national scientific performance (6–10).

The aim of this paper was to analyse bibliographic output of the Institute in the period from 1994 to 1998. The organisation of scientific, professional, and other activities of the Institute in that period can be divided in two phases. The first phase lasted until 1996; most of the activities were organised within 18 research projects supported by the Ministry of Science and Technology of the Republic of Croatia. The second phase started in 1996, upon the adoption of the National Scientific Research

Program (11). From then on, the Institute's activities have been organised within three programmes of permanent scientific research comprising 20 specific research projects and five incentive projects for young researchers. In addition, there were 15 projects with other institutions in Croatia, eight with institutions in Germany, Italy, UK, and USA, and 10 with international organisations (WHO, IAEA, EU, and Alps/Adria Community) (12).

Several indicators can be used in evaluating the research quality of an institution. Those include the number of publications, number of citations of authors' publications, external peer evaluation, number of obtained Ph.D. degrees, awards for distinguished scientific contribution, and finances allocated to research. This paper gives an overview of the Institute's scientific performance by analysing the number and type of publications produced by its researchers with respect to the number of scientists and their scientific field.

DATA SOURCES

We analysed two groups of data: the Institute's personnel data and bibliographic data on all types of documents produced by the Institute's researchers.

The main sources were the official annual reports of the Institute (13–17). Additional data were gathered using the Institute for Scientific Information (ISI) Current Contents (CC) bibliographic database (18), Ulrich's International Periodicals Directory 1999 (19), Journal Citation Report (JCR) 1997 Science Edition (20), and JCR 1977 Social Science Edition (21). ProCite4®–Demo software was used to handle bibliographic references (22).

RESULTS AND DISCUSSION

Employees

The Institute's publications were the result of work of a small number of researchers (Table 1). Between 48% and 44% of the Institute's employees consisted of technical and administrative staff supporting the research. The number of all employees decreased from 181 in 1994 to 151 in 1998. The decrease did not start in 1994, but was also observed in the 1988–93 period (4). The number of employees with the university degree was decreasing until 1996, when the new research programs started. From then on, the number of employees with the university degree did not change. In that period, the number of employees with a Ph.D. degree varied from 53 to 48, of those with a master's degree from 24 to 16, and of those with a bachelor's degree from 17 to 21. Although the number of researchers with a Ph.D. slightly decreased, these results together with those from the previous six-year period did not reveal a trend (4). Unlike the researchers with the Ph.D. degree, researchers with the master's degree showed a continuing trend of decrease from the previous period. The number of young researchers with the bachelor's degree started to increase in 1997. By the end of 1998, the number of young researchers approached the number observed at the end of the 80s when their number was the highest (4). Due to a small number of research institutions in Croatia, the career of a scientists is often tied to one institution.

Table 1 *Number and education of employees*

Year	Employees							
	University degree				Non-university degree			Total
	Ph.D.	M.Sc. M.A.	B.Sc. B.A. M.D.	Total	Non-university colleges	Secondary school	Basic school	
1994	53	24	17	94	10	60	17	181
1995	53	20	15	88	8	59	15	170
1996	52	19	14	85	8	55	13	161
1997	50	17	18	85	7	54	11	157
1998	48	16	21	85	6	48	12	151

This means that the increase in the number of young researchers may stop the decrease in the number of senior researchers at some point in future. Of course, this may be the case only if the national policymakers and the Institute hold to that objective.

Of 85 employees with the university degree, 82 were researchers. They attained their bachelor's degree (Table 2) in natural, technical, or biotechnical sciences (63%),

Table 2 *Employees with a university degree (on 31 December 1998) by scientific area and field in which they received bachelor's degree*

Scientific area and field	N	% (82=100%)
NATURAL, TECHNICAL, AND BIOTECHNICAL SCIENCES	52	63
Chemistry	21	26
Biology	9	11
Chemical and Textile Technology	8	10
Food Technology and Biotechnology	6	7
Physics	5	6
Mathematics	3	4
BIOMEDICAL SCIENCES	27	33
Medicine	18	22
Medical Biochemistry and Pharmacy	6	7
Veterinary Medicine	3	4
SOCIAL SCIENCE AND HUMANITIES	6	4
Psychology	3	4
Economy *	2	–
Languages and Literature *	1	–
ALL AREAS/FIELDS	85	

* Do not participate in research.

biomedical sciences (33%), and social science (4%). Three relatively largest groups of researchers received the bachelor's degree in chemistry, medicine, and biology. Chemistry and medicine ranked the same as in the 1988–93 period, while biology overtook physics at the third place.

The analysis of fields in which 43 scientists with a Ph.D. degree were appointed to scientific grades sheds a somewhat different light on research at the Institute (Figure 1). The fields in which they applied for the appointment were the result of research topics they studied and on which they published papers. Most Institute's scientists, 32 altogether, were appointed to scientific grades in medicine. Researchers appointed to scientific grades in other fields were either single in the field or formed groups of 2–5 scientists. Medical research was divided in three sub-fields: public health (18 scientists), basic medical sciences (11 scientists), and clinical medicine (3 scientists).

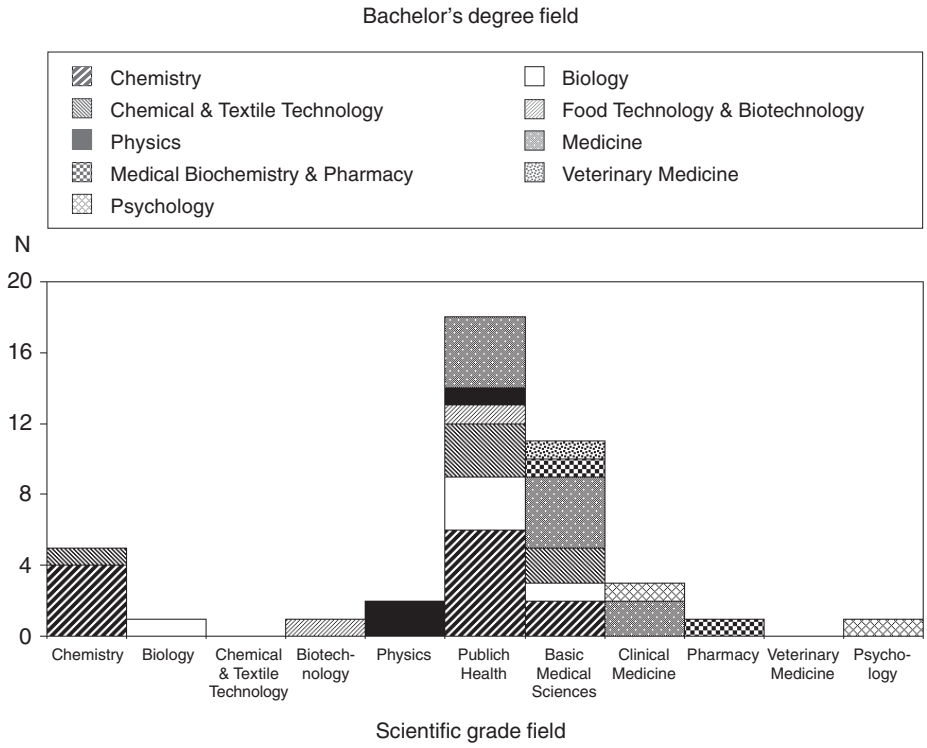

Figure 1 *Number of scientists (N) holding a Ph.D. degree (on 31 December 1998) by the area and field in which they received the bachelor's degree and by the area and field in which they were appointed into the scientific grade*

Publications

The number of publications is frequently used as an indicator of quality of research. The fact that research is published suggests that it has quality. This is further evaluated by identifying the type of publication, existence or absence of a peer reviewing procedure, and whether it is published in a journal that is indexed by selective indexing services such as *Current Contents* (CC), *Science Citation Index* (SCI), *Social Science Citation Index* (SSCI), or *Arts & Humanities Citation Index* (A&HCI). In this paper, publications were divided in seven broad categories: scientific papers, conference abstracts, technical papers, books, book chapters, theses, and other publications. Categories of scientific and technical papers were further divided in conference proceedings and journal articles. Journal articles were divided in accordance with journal coverage by certain abstracting/indexing services (Tables 3 and 4).

Table 3 T*ype and number of publications*

Type of publication	Year					All	%
	1994	1995	1996	1997	1998		
Scientific papers							
Papers in journals covered by CC	32	43	28	28	24	155	13
Papers in journals covered by other indexing services	25	17	26	13	10	91	8
Papers in journals not covered by indexing services	4	1	2	6	0	13	1
Conference proceedings	37	19	55	31	29	171	15
Conference abstracts	108	96	125	65	119	513	44
Technical papers							
Papers in journals covered by CC	1	0	1	1	0	3	< 1
Papers in journals covered by other indexing services	10	13	4	11	6	44	4
Papers in journals not covered by indexing services	2	4	4	4	2	16	1
Conference proceedings and special publications	6	3	9	9	1	28	2
Books (authors/editors/translations)	2	0	8	1	3	14	1
Book chapters	7	4	5	3	4	23	2
Theses of the Institute's students	8	9	3	4	6	30	3
Theses of external students supervised by the Institute's scientists	5	8	8	10	9	40	3
Other (articles in newspapers, magazines and other publications)	8	2	13	0	3	29	2
Total	255	219	291	186	216	1167	100

Table 4 *Abstracting/indexing coverage of scientific papers published in journals*

Abstracting/Indexing Service*	No. of papers	No. of journals
CC – LIFE	78	43
CC – BEHA	24	5
CC – PHYS	22	10
CC – CLIN	17	6
CC – AGRI	13	8
CC – TECH	1	1
All CC Editions	155	73
Biological Abstracts, Chemical Abstracts, C.I.S. Abstracts, Ergonomic Abstracts, Excerpta Medica, Index Medicus and other abstracting/indexing services**	91	21
No abstracting/indexing service**	13	8
Total	259	103

* CC – AGRI = Current Contents/Agriculture, Biology & Environmental Sciences
CC – BEHA = Current Contents/Social & Behavioral Sciences
CC – CLIN = Current Contents/Clinical Medicine
CC – LIFE = Current Contents/Life Sciences
CC – PHYS = Current Contents/Physical, Chemical & Earth Sciences
CC – TECH = Current Contents/Engineering, Computing, & Technology
Some papers were covered by two editions of CC. The majority of them were covered both by LIFE and some other CC edition. Such papers are presented in the table only in one CC edition.

** According to Ulrich's International Periodicals Directory [CD-ROM], RR Bowker, New York, Winter 1999.

The primary sources of reference data used in this paper were the Institute's annual reports. The criterion for the inclusion of a publication in a report was that at least one author was the Institute's employee at the time of publication. The Institute's reports also included papers of scientists who participated in foreign research, but who clearly declared their affiliation with the institute, at least in the footnote.

Between 1994 and 1998, the Institute's researchers published 1167 publications, of which 430 (37%) scientific papers, 513 (44%) conference abstracts, and 91 (8%) technical papers. They were authors, editors, or translators of 14 books, and authors of 23 chapters in books. Thirty young researchers from within the house completed their thesis (16 Ph.D., 13 M.Sc., and one B.Sc.) and 40 students from other institutions completed their research under the supervision of the Institute's scientists (two Ph.D. theses, 11 M.Sc. theses, and 27 B.Sc. theses).

Papers published in journals covered by CC have the highest rank which corresponds to the selection procedure for the inclusion of journals in that eminent bibliographic database. Their impact can further be traced through SCI, SSCI, or A&HCI. Moreover, production of CC papers is easily compared with other research institutions. In the period 1994–1998, the Institute's researchers published 155 scientific papers covered by CC. This included 149 articles, three reviews, two letters, and one note. In addition, three technical papers were published in journals covered by CC. In other words, the annual average was 31 CC papers. The number of published papers varied over the observed period. These variations might be related to the two research

funding cycles. The number of CC articles peaked in 1995, the last year of the first funding cycle 1990–1995. Accordingly, the other peak may be expected for the year 1999/2000 when the current funding cycle will probably end.

Years 1994–1998 saw 711 names appear as authors of 155 papers. The distribution of the number of authors was positively skewed, with the range from one to 24, and the median of 4 authors per paper. One to six authors published 85.8% of papers, which corresponds to the overall Croatian statistics for one to five authors in years 1990–92 (8). Of 711 authorial appearances, there were 314 different names. However, only an extensive analysis would be able to pinpoint the exact number of authors. Namely, more author share the same family name and the first name initial, the name of one author may be quoted differently, and errors in indexing names are quite common. In comparison with the previous six-year period, more people co-authored an average Institute's paper covered by CC (mean=3.5 vs. mean=4.6, respectively). It remains to be seen whether the increase is pertinent to the Croatian and world trends or this is specific for the Institute.

We used CC as the secondary source of bibliographic data. The database search revealed that CC covered a total of 4,732,508 papers between 1994 and 1998. CC indexed 4,751 papers that listed at least one author address in Croatia. Thus, the Croatia's share of papers in sciences, social science, and art and humanities was 0.10% in that period. The CC database search revealed that the respective production of Norway and Finland, countries with similar population, was 23,902 and 32,613 in the same period. In other words, their share in sciences exceeded the Croatian 5 to 7 times.

Of Croatian papers covered by CC, 124 listed at least one author's affiliation with the »*inst med res & occupat hlth*«. The discrepancy in the number of papers retrieved from CC and the number of CC papers quoted in the Institute's reports resulted from the usage of a non-unified name of the Institute (»inst med istrazivanja & med rada« or »inst med & occupat hlth«; 3 papers), mistaken affiliation (»hrvatska akad med znanosti«; 1 paper), or the editorial policy of one journal which stated the affiliation only of the first author (12 papers[1]). In addition, papers of the Institute's scientists doing research in foreign countries could not be retrieved due to the fact that their affiliation with the Institute was stated only in a footnote. When no corrections were made for errors or difference in affiliation, and 124 was taken as the number of CC papers, the Institute's share in Croatian science covered by CC was 2.61%. By the end of 1998 the Ministry of Science and Technology of Croatia registered 6,496 scientists with a Ph.D. degree (23) of whom 48 were from the Institute. This fact suggests that the Institute's production is above its share of scientists in the Croatia's total.

A comparison of ratios of published CC papers and scientists who held Ph.D. degrees between the period 1988–93 and the 1994–98 period (4) reveals a slight decrease in the productivity in the latter (Table 5). On the other hand, the number of published conference abstracts doubled.

The Institute has been quoted in several publications dealing with the scientific production of researchers from Croatia (6, 8, 10). A comparison between the Insti-

[1] Published in Collegium Antropologicum

Table 5 *The ratio of the total number of publications by category (n) and the number of employees with Ph.D. or all employees with university degree (N) in the five-year period*

Degree	Scientific papers covered by CC			Scientific papers not covered by CC [1]		Books and chapters [2]		Technical papers [3]		Conference abstracts	
	N	n	n/N	n	n/N	n	n/N	n	n/N	n	n/N
Ph.D.	256	155	0.605	275	1.074	36	0.145	91	0.355	513	2.004
University degree	437	155	0.355	275	0.629	36	0.085	91	0.208	513	1.174

[1] Scientific papers in journals covered by other indexing services or not covered, and conference proceedings
[2] Books (authors, editors, and translations), book chapters, and textbooks
[3] Technical papers in all journals, conference proceedings, and special technical publications

tute's scientific production and other institutions of similar organisation and scope of research may give useful guidelines for a future science policy. A recent annual report (24) of the Institute Ruđer Bošković (IRB) covers the scientific production of the IRB staff for the period 1989–1998. We evaluated the number of publications and the number of scientists with a Ph.D. degree from the histogram displayed in the report (24) and found that the average annual ratio of published CC papers and scientists who hold a Ph.D. degree was 1.17. The Institute's ratio was 0.79 for the period 1988–93 (4) and 0.60 for the period 1994–98. On the average, the Institute's production is 60% lower than that of IRB. However, many authors quote the Institute as one of the top three institutions in Croatia in the number of publications and citations of particular authors (6, 9, 10). Furthermore, although the overall Croatian scientific production is low in comparison to other countries, *Divić* (7) has shown that Croatian science stands second only to Denmark in papers published per dollars invested.

The Institute's authors published in journals from 11 standard fields of the ISI National Science Indicators (25) (Table 6). Most papers were published in clinical

Table 6 *Scientific fields and the impact factors (IF) of the journals*

Standard fields of ISI National Science /U.S. University Science / Institutional Indicators	No. of journals	No. of papers	IF of journals		
			Minimum	Maximum	Median
Clinical Medicine	17	36	0.162	2.780	1.34
Biology & Biochemistry	16	28	0.283	6.960	2.14
Chemistry	13	26	0.244	2.740	1.11
Social Science, General	2	17	0.191	0.331	0.26
Pharmacology	7	16	0.487	15.100	1.07
Ecology/Environment	7	12	0.519	2.120	0.95
Molecular Biology & Genetics	6	9	0.712	5.080	1.74
Psychology/Psychiatry	3	7	0.256	0.305	0.27
Neurosciences	2	2	1.660	2.400	2.03
Engineering	1	1	0.128	–	–
Plant & Animal Sciences	1	1	0.408	–	–

medicine, biology and biochemistry, chemistry, general social science, and pharmacology. The impact factors (IF) range from 6.96 (biology and biochemistry) to 0.128 engineering. A review journal in the field of pharmacology even increased the range to 15.1. The journal impact factor is high in large, basic research fields with rapidly growing and short-living literature that uses many references per article, but does not necessarily reflect the research quality of papers published in the journal (26). The value of the impact factors greatly depends on the research field. The Institute's researchers work in many different fields and it would not be appropriate to compare their papers on the basis of impact factors of the journals in which they published.

Published papers dispersed through 69 journals indexed in SCI and five journals indexed in SSCI. A total of 133 papers was indexed in SCI, including 2 technical papers. There were 25 papers indexed in SSCI, one of which was technical. Tables 7 and 8 list journals with two or more papers. Our comparison revealed that the *American Journal of Industrial Medicine* published the highest number of papers from the area of SCI, whereas *Collegium Antropologicum* from the area of SSCI.

Table 7 *Journals indexed in SCI in which two or more papers were published*

	Journal	No. of papers
1.	Am J Ind Med	10
2.	Int Arch Occup Environ Health	8
3.	Croat Chem Acta	6
4.	J Coord Chem	6
5.	Am J Physiol	5
6.	Mutat Res	5
7.	Pharmacol Toxicol	4
8.	Arch Toxicol	3
9.	Chem Res Toxicol	3
10.	Environ Monit Assess	3
11.	J Appl Toxicol	3
12.	J Environ Radioactiv	3
13.	Analyst	2
14.	Ann Allergy	2
15.	Bull Environ Contam Toxicol	2
16.	Environ Health Perspect	2
17.	Eur J Clin Chem Clin Biochem	2
18.	Exp Toxicol Pathol	2
19.	Int J Legal Med	2
20.	J Biol Chem	2
21.	J Expo Anal Environ Epidemiol	2
22.	J Radioanal Nucl Chem Lett	2
23.	J Trace Elem Exp Med	2
24.	Kidney Int	2
25.	Monatsh Chem	2
26.	Pflugers Arch	2
27.	Protein Sci	2
28.	Toxicol Lett	2

Table 8 *Journals indexed in SSCI in which two or more papers were published*

	Journal	No. of papers
1.	Collegium Antropol	16
2.	Work Stress	4
3.	Stud Psychol	2

Finally, the Institute published scientific and technical papers in 42 journals not indexed in SCI, SSCI, or CC. That number totals 164 papers: 104 scientific and 60 technical. Table 9 lists the journals with two or more papers published. The leading journal in that category was the *Archives of Industrial Hygiene and Toxicology* (*Arh hig rada toksikol*) which published 60 (36.6%) papers. The journal primarily covers occupational and environmental health and toxicology and is covered by Index Medicus and other abstracting services.

Table 9 *Journals not covered by CC in which two or more papers were published. (Number of technical papers in brackets)*

	Journal	No. of papers	
1.	Arh hig rada toksikol *	60	(21)
2.	Period biol *	12	
3.	Liječnički vjesnik *	10	(6)
4.	Sigurnost *		(9)
5.	Environ Managem Health *	8	
6.	Kem ind *	6	(2)
7.	Acta Med Croatica *	4	(1)
8.	Acta Pharm *	4	
9.	Environ Res Forum	4	
10.	NeT		(4)
11.	Reumatizam *	4	(2)
12.	Croatian Med J *	2	
13.	Hrvatski meteorološki časopis	2	
14.	Hrvatske vode		(2)
15.	Medicina		(2)
16.	Neurol Croat*	2	(1)
17.	Rad HAZU	2	
18.	Tonovi Zagreb		(2)

* Covered by Biological Abstracts, Chemical Abstracts, C. I. S. Abstracts, Ergonomic Abstracts, Excerpta Medica, Index Medicus or other abstracting/indexing services

CONCLUSION

The analyses described in this paper gave some notion about the research of the Institute for Medical Research and Occupational Health between 1994 and 1998 and made it possible to compare it with the previous, 1988–1993 period.

In those 11 years, the staff reduced greatly (from 275 to 151). The reduction of university level employees was the most pronounced in the group of those with master's degree. So far, the increase in the number of young researchers with the bachelor's degree, employed to attain master's degree and a Ph.D. degree, has put a stop to the reduction of the Institute's researchers.

The share of the Institute's papers in the Croatian corpus indexed by CC exceeded the share of Institute's scientists in the Croatian total. The observed variations in the number of CC papers over the 1994–98 period may be related to cycles in research funding. Further analysis is needed to explain the small drop in production of papers and increase in co-authorship with respect to the 1988–94 period.

The production analyses of the Institute's researchers who work in a variety of fields should proceed with great caution and take into account that research productivity, citation rates, and impact factors depend on the research field.

Uniform quotation of the Institute's name and address, as well as of the author's names, should prevent the omission of published papers from relevant reports and analyses in the future scientometric studies.

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Sažetak

BIBLIOGRAFSKO STVARALAŠTVO INSTITUTA ZA MEDICINSKA ISTRAŽIVANJA I MEDICINU RADA U ZAGREBU IZMEĐU 1994. I 1998. GODINE

Svrha rada bila je analiza znanstvene djelatnosti Instituta u proteklom petogodišnjem razdoblju. Analiziran je broj publiciranih radova i znanstvena područja u kojima istraživači i znanstvenici rade. Radovi su razvrstani u kategorije prema tipu publikacije i njihovoj uključenosti u različite bibliografske baze/publikacije. Razlikuju se: znanstveni i stručni radovi referirani u Current Contents bazi, radovi referirani u drugim neselektivnim bibliografskim bazama/publikacijama, radovi koji nisu citirani u sekundarnim bazama/publikacijama i radovi objavljeni u kongresnim zbornicima, zatim sažeci kongresnih priopćenja, knjige i poglavlja u knjigama, kvalifikacijski radovi institutskih istraživača i vanjskih suradnika, čiji su mentori iz Instituta te ostale publikacije. Dobiveni rezultati uspoređeni su sa znanstvenom djelatnošću Instituta u prethodnom šestogodišnjem razdoblju te djelatnošću drugih znanstvenih institucija u zemlji i svijetu. Usprkos smanjenju ukupnog broja zaposlenika u proteklom periodu, broj znanstvenika s doktoratom znanosti ostao je nepromijenjen. Odnos broja radova u časopisima pokrivenim s Current Contents i broja doktora znanosti ima tendenciju smanjenja, dok se taj odnos za broj sažetaka kongresnih priopćenja udvostručio. Bibliografsko stvaralaštvo Instituta više je od prosjeka publicističke aktivnosti znanstvenika u Hrvatskoj. Dane su tehničke preporuke kako ujednačiti imena autora i institutsku adresu te tako sačuvati radove citirane u različitim bibliografskim bazama za buduće scientometrijske analize.

Ključne riječi:
bibliografska analiza, broj publikacija, koautorstvo, odjek časopisa, vrsta publikacije, znanstveno područje

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