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**Medical Research in Norway
– Bibliometric Indicators**

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Preface

The objective of this report is to provide a bibliometric profile of medical research in Norway. The presentation gives a short overview of different macro indicators based on scientific publishing, including analyses of the citation and collaboration patterns of Norway. The report is written on request from the Research Council of Norway and function as a background report for the evaluation of clinical, epidemiological, public health, health-related and psychological research in Norway.

Oslo, April 2003

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Summary

This report shows that Norway has a positive specialisation in Clinical Medicine and Psychology/Psychiatry. This means that Norway has a higher share of its journal articles in these fields than what is the average for all countries. Norway contributes to 0.7% of the world production in both fields while the average for Norway in all fields is 0.55%. Still, in Clinical Medicine the specialisation was even stronger 20 years ago and the Norwegian article production has not increased as much as the world average of the field. The last 5 years Norwegian researchers have published approximately 1200-1400 scientific papers annually in Clinical Medicine and 140-170 articles annually in Psychology/Psychiatry. In both fields Norwegian researchers collaborate extensively with researchers from other countries: In Clinical medicine 40% of the publications were co-authored by researchers from abroad, while the corresponding share in Psychology/Psychiatry was 32%. The scientific impact as reflected through citations is higher than the world average in Clinical Medicine. In Psychology/Psychiatry the articles are generally cited below the world average.

The analysis of medical subfields shows that Norway has a strong positive specialisation in public health and contributes to 1.2% of the world-production in the field Public, Environmental & Occupational Health. Similarly, the specialisation is very strong in Oncology. The Norwegian publications are cited significantly above average in Allergy, Ergonomics, Gerontology, Medical Laboratory Technology, Transplantation, and Urology & Nephrology. To the contrary, the citation rates are very low in the subfields Ophthalmology, Otorhinolaryngology, Substance Abuse, and Neuroimaging.

1 Introduction

This study is based on bibliometric data provided by Institute for Scientific Information (ISI), which is the producer of the most important database for bibliometric purposes. The database can be used to measure two basic parameters: 1) the extent of publishing in international scientific journals, and 2) the extent to which these papers have been referred to or cited in the subsequent scientific literature. In turn, these indicators represent indirect measures for knowledge production and of scientific impact and international visibility. Through a bibliometric survey information is thereby provided on the structure and output of the nation's research system.

In the report we present indicators of both kinds. One standard indicator is the number of papers in different scientific/medical fields. As a relative indicator this number is also related to the population size of the country. Differences in countries' population size may, however, not necessarily correspond to differences in research efforts (e.g. amount invested on R&D). A better measure would therefore be to relate the publication output to input data (e.g., R&D resources and R&D person years). However, due to methodological restraints, it is difficult to produce reliable indicators on input-output ratios. We have also calculated the Norwegian contribution of papers to the world total production in different scientific and medical subfields. This indicator can be used to tell whether Norway has a higher or lower share of its publication in a particular subfield than what is the average for all countries (relative specialisation). Thus, the indicator characterises the internal balance of fields within a country, but is not an expression of the output in absolute terms.

The basis for the citation indicators is the citations to former scientific publications, which can be identified from the reference lists of the research publications. These data are systematically collected by ISI, and this makes it possible to conduct studies of citation patterns at aggregated levels. One standard indicator is the average number of citations received by a country's scientific papers. This measure can in turn be compared with the world-average or with the average of particular countries. The indicator is often presented as a relative citation index. Then the indicator tells whether a country's publications are cited above or below the world average (100). There are different opinions on the meaning and validity of citations as indicators, not to be discussed here. Generally, citations can be considered as an indirect measure of the attention given a nation's research results by the international scientific community. Thus, they can be used in order to assess aspects related to scientific impact and international visibility.

The main focus of this report is on the latest 5-year period 1998-2002, but we have also included data back to 1981. Within the scope of this project it has only been possible to include a limited number of indicators and analyses. Still, the report gives an overview of some main bibliometric patterns within medical research of Norway.

1.1 Data and methods

The ISI database applied in this study covers a large number of specialised and multidisciplinary journals, including all influential peer reviewed journals in the natural sciences, medicine and technology. In addition it has a more limited selection of journals in the social sciences and the humanities. In general, the ISI database is regarded as constituting a satisfactory representation of international mainstream research (Katz & Hicks, 1998). Thus, it allows the construction of comparable indicators on e.g. the scientific output, productivity and impact of a country.

However, the database has certain limitations that are important to consider when interpreting the results. Generally, the ISI-database is most suitable with respect to academic research in which publication in international journals represents the main mode of communication. The coverage varies between different subfields. Highest coverage is obtained for physics, chemistry, biomedicine and clinical medicine. In biology and technology the coverage is generally somewhat lower. In the social sciences and humanities the coverage tends to be poorer, due to a less centralised or different pattern of communication. In the two latter fields, publishing in books typically is more common than in international journals.

In respect to medicine, the database is, however, well suited. It can be assumed that the database covers the large majority of scientific production in medicine. Still it is important to be aware that the Norwegian journal "The Journal of the Norwegian Medical Association" is not covered. This journal is not international but is of course an important publication channel for the dissemination of research results within Norway.

In the study we have applied different bibliometric products/databases. One is the National Science Indicators (NSI), containing aggregated publication and citation counts for 24 or 105 different scientific fields (Standard version and De luxe version, respectively). The database covers more than 6000 different journals representing the natural sciences, medicine, the social sciences and the humanities. In addition we have applied the database National Citation Report (NCR) for Norway, containing bibliometric information for individual articles from Norway. We have also applied the Journal Performance Indicators database (JPI) containing bibliometric data for individual journals. The JPI database covers 10770 journals that have obtained more than 100 citations during the period 1981-2002. The analyses are based on the main article types, that is, regular articles, notes, reviews, and proceedings papers in all journals indexed. Other types of items such as editorials, abstracts, etc. are not included. As a basic principle, an article is assigned to a particular country when it has at least one author address from this country.

The method underlying the classification of scientific fields involves journal indexing. Here, a field is defined by the sample of journals that are classified under that field. Each journal is usually classified in one field (but sometimes two or more). All articles in a journal are regarded as belonging to that journal's field of science. That is, it is the journal an article has been published in that determines which field the article is assigned to. This method of classification has obvious limitations (Aksnes, Olsen, & Seglen, 2000). Particularly it will be problematic for journals containing articles from a

broader range of subdisciplines. In turn, this has consequences for how representative the different categories will be. Furthermore, because some journals are classified into more than one subfield the categories will partly be overlapping. Despite such limitations the system of classification still provides valid information by allowing direct comparisons between the publication activities of countries in fixed journal sets. A list of the journals that are included under the different subfields can be found at ISI's web page (<http://www.isinet.com/cgi-bin/jrnlst/jlsubcatg.cgi?PC=D>).

In the report we have compared the performance of Norway with the world-average or with the performance of a selected set of countries.

2 The overall picture – Norway

In the latest 5-year period, 1998-2002, Norway accounted for 0.55 percent of the world production of scientific publications (Table 1). This percentage has been fairly stable the last decades. In total the Norwegian production amounted to 24000 articles. Measured as number of articles per 1000 capita, Norwegian scientists produced 5.4 articles during this 5-year period. With this Norway ranks as number 10 of the 22 OECD countries that have been selected for comparison.

Table 1. Scientific publishing in selected countries. Total number of articles 1998-2002.

Country	Number of articles	Share of world production*	Number of articles per 1000 capita
Switzerland	67453	1.51 %	9.4
Sweden	74111	1.66 %	8.4
Denmark	37942	0.85 %	7.1
Finland	35550	0.80 %	6.9
Netherlands	93457	2.09 %	5.9
UK	345466	7.73 %	5.8
Iceland	1616	0.04 %	5.8
New Zealand	21675	0.49 %	5.7
Australia	105306	2.36 %	5.5
Norway	24375	0.55 %	5.4
Canada	166504	3.73 %	5.4
Belgium	49451	1.11 %	4.8
USA	1267948	28.39 %	4.6
Austria	34693	0.78 %	4.3
Germany	322969	7.23 %	3.9
France	233850	5.24 %	3.9
Ireland	13388	0.30 %	3.5
Japan	344200	7.71 %	2.7
Spain	108272	2.42 %	2.7
Italy	151799	3.40 %	2.6
Greece	23885	0.53 %	2.2
Portugal	15116	0.34 %	1.5

*) Number of articles divided by the sum of all countries' article production.

Source: NIFU/ISI (NSI).

Table 2 shows the relative citation index (total all fields) for the 22 countries for the period 1998-2002. The world average is represented by an index value of 100. There are large differences in the citation rates among different scientific disciplines. An article in molecular biology is for example on average cited 10 times as often as an article in mathematics. This means that a country's overall citation rate will depend upon the relative distribution of its papers within different scientific disciplines. Relatively many papers within highly cited fields would significantly increase a country's overall citedness. In order to adjust for such differences we have weighted the relative citation rates according

to a worldwide (average) field distribution of articles. Thus, this gives an indicator that allows direct international comparisons.

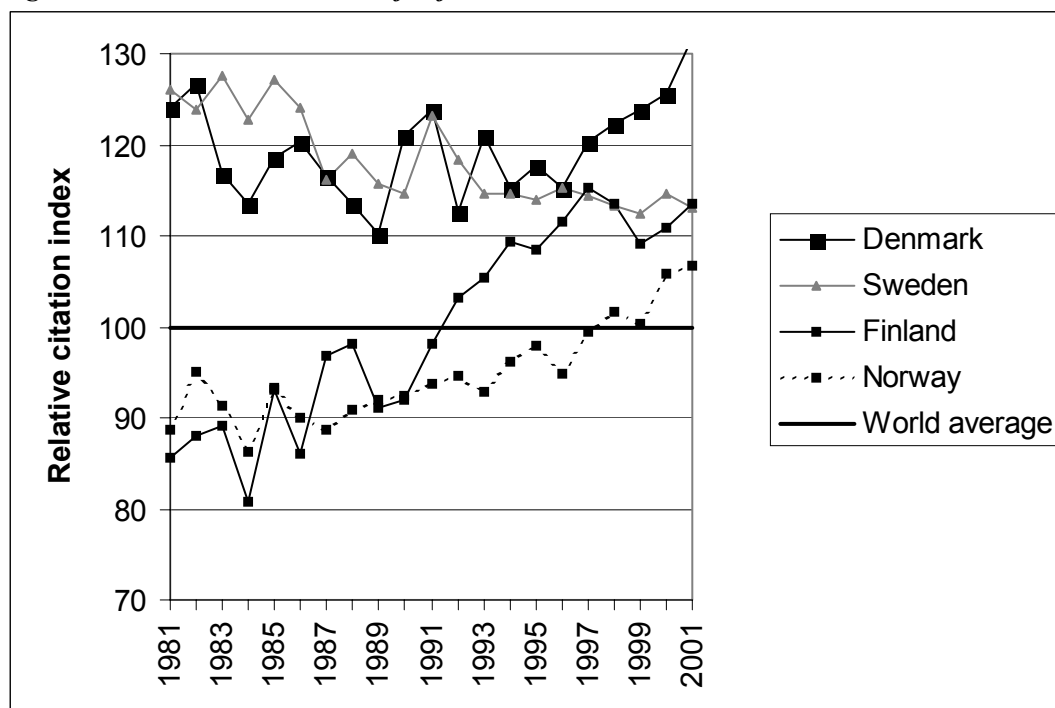
Table 2. Relative citation index for selected countries, 1998-2002.*

Country	Relative citation index	Country	Relative citation index
Switzerland	141	Norway	103
USA	138	Australia	103
Netherlands	127	Austria	102
Denmark	125	Ireland	102
UK	121	Italy	101
Canada	118	New Zealand	97
Sweden	113	Iceland	97
Belgium	111	Spain	88
Germany	110	Japan	84
Finland	110	Portugal	83
France	104	Greece	69

*) Based on the papers published during 1998-2002 and citation counts to those papers within the same 5-year window. The indicators have been weighted according to a world-average field distribution of articles. Source: NIFU/ISI (NSI).

In terms of citation rate, Norway ranks as number 12 of the 22 countries that have been selected for comparison. The citation index is 103. That is, the Norwegian articles are cited marginally (3%) above the world average.

Figure 1. Relative citation index for four Nordic countries, 1981-2001.*



*) Based on annual publication windows and accumulated citations to these publications. The indicators have been weighted according to a world-average field distribution of articles. Source: NIFU/ISI (NSI).

For a long time, the Norwegian publications have been cited below the world average. This is evident from Figure 1, which shows the annual relative citation index for four Nordic countries for the period 1981-2001. As we can see it was not until the end of the 1990ies that Norway passed the world average.

Norway has a distinct scientific profile. This is reflected in the specialisation index. As previously mentioned this index states whether a country has a higher or lower share of its publications in a particular subfield than what is the average for all countries. In Table 3 we have calculated this index for selected fields using publication data for the period 1998-2002. In this table we have also included the citation index for each field. For both indicators the relative standing is described by seven categories, varying from score far above average (+ + +) to far below average (– – –). When interpreting the indicators one should consider that the size of the different subfield varies considerably.

Generally, Norway has a high relative publication activity in the geosciences and biology. In contrast, we find a de-specialisation in all the “hard” sciences. This scientific profile has been described as a “bio-environmental model”, that is, the pattern most typical for developing and more ‘natural’ countries (e.g. Australia or South Africa) with Biology and Earth and Space Sciences in the main focus” (Glänzel, 2000).

In biomedicine and clinical medicine the picture is heterogeneous. We find a positive specialisation in Clinical medicine, Immunology and Physiology. In Biochemistry & Biophysics, Molecular Biology & Genetics and Pharmacology the publication share is lower than “expected”. In biomedicine and Psychology/Psychiatry the articles are generally cited below the world average. These publication patterns will be further analysed below.

Table 3. Bibliometric performance indicators for Norway in selected fields. Relative specialisation* and citation impact (relative citation index), 1998-2002.**

Field***	Specialisation	Citation impact	Field***	Specialisation	Citation impact
Biology			Geosciences		
<i>Plant Sciences (2%)</i>	+	-	<i>Earth Sciences (6%)</i>	+++	0
<i>Animal Sciences (2%)</i>	+++	++	<i>Geol/Petrol/Mining Engn (1%)</i>	+++	+
<i>Aquatic Sciences (5%)</i>	+++	+	Physics/chemistry		
Microbiology (2%)	0	0	Physics (6%)	--	+
Ecology/Environment (5%)	+++	++	Space Science (1%)	-	0
Agricultural Sciences (2%)	+	+	Chemistry (7%)	--	0
Biomedicine			Mathematics (1%)	-	++
Biochemistry & Biophysics (3%)	-	-	Technology		
Molecular Biol. & Genetics (2%)	-	-	Materials Science (2%)	----	0
Neuroscience & Behaviour (3%)	0	0	Engineering (5%)	--	0
Immunology (2%)	++	-	Social sciences		
Pharmacology (2%)	-	-	Social Science general (4%)	+	0
Physiology (1%)	+++	--	Economics/Business (2%)	++	-
Medicine					
Clinical Medicine (26%)	+	+			
Dentistry/Oral Sur. & Med (1%)	+++	+			
Psychology/Psychiatry (3%)	+	-			

*) Share of Norway's publications within a scientific field divided by the corresponding worldwide average.

**) Average number of citation received by Norway's publications divided by the corresponding worldwide average.

***) The fields share of the total Norwegian article production in parenthesis.

Key to the symbols:

+++ More than 50% above average (index: > 150)

++ 30-50% above average (index: 130-150)

+ 10-30% above average (index: 110-130)

0 Average (index: 90-110)

- 10-30% below average (index: 70-90)

-- 30-50% below average (index: 50-70)

---- More than 50% below average (index: < 50)

Source: NIFU/NSI, Institute for Scientific Information. The fields are based on the NSI-Standard database, in addition a few categories from the de-luxe database have been included (in italics). Altogether the selected fields cover more than 90% of the journal publishing in the natural sciences, medicine and social sciences.

3 Bibliometric indicators of medicine – broad field categories

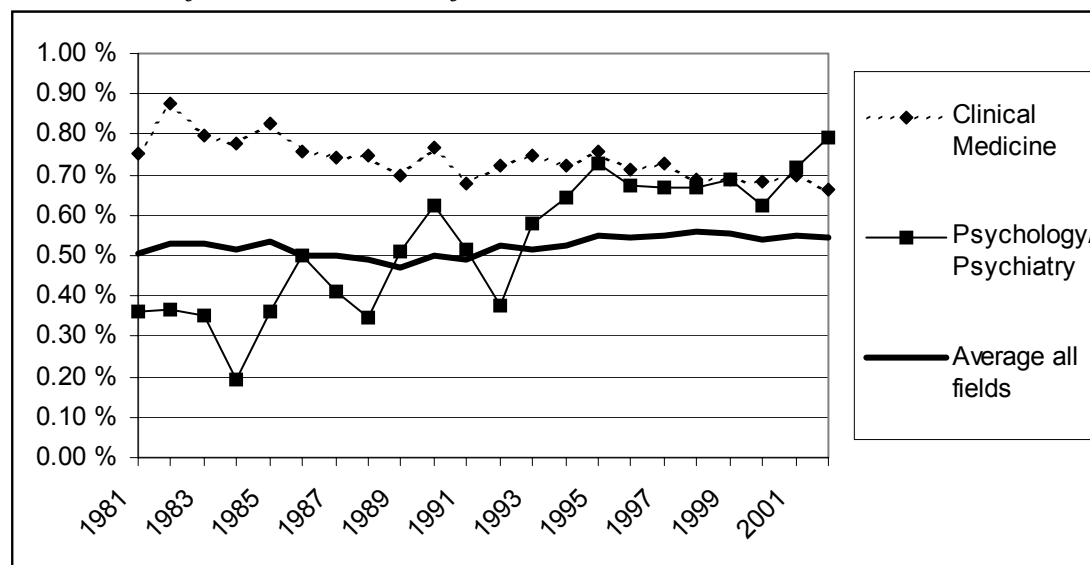
In this section we will present bibliometric indicators for two broad field categories: Clinical Medicine and Psychology/Psychiatry. These indicators have been calculated using the NSI/NCR database.

3.1 Citation and publication indicators

Clinical Medicine is a large category accounting for 26% of the total Norwegian article production. The last 5 years the number of scientific papers published by Norwegian researchers has been in the range of 1300 to 1400 annually. This represents approximately 0.7% of the total world production of articles within the field. Thus the share is higher than what is the average for Norway in all fields (0.55%). In other words, Norway has a positive specialisation in Clinical Medicine. In Figure 2 we have calculated the annual shares for the period 1981-2002 for Clinical Medicine and Psychology/Psychiatry. For Clinical Medicine we find a marginal decrease during the period, although in absolute terms the annual number of articles shows a significant increase.

Psychology/Psychiatry is a much smaller field accounting for only 3% of the total Norwegian article production. The last 5 years Norwegian researchers have published approximately 140-170 articles annually. Still, Norway has a positive specialisation in the field: the Norwegian share of the articles in the field (0.7%) is higher than what is the average for Norway in all fields (0.55%). Figure 2 shows that this share has been increasing significantly during the last two decades. In 1981 Norwegian researchers only contributed to 0.4% of the world production in Psychology/Psychiatry.

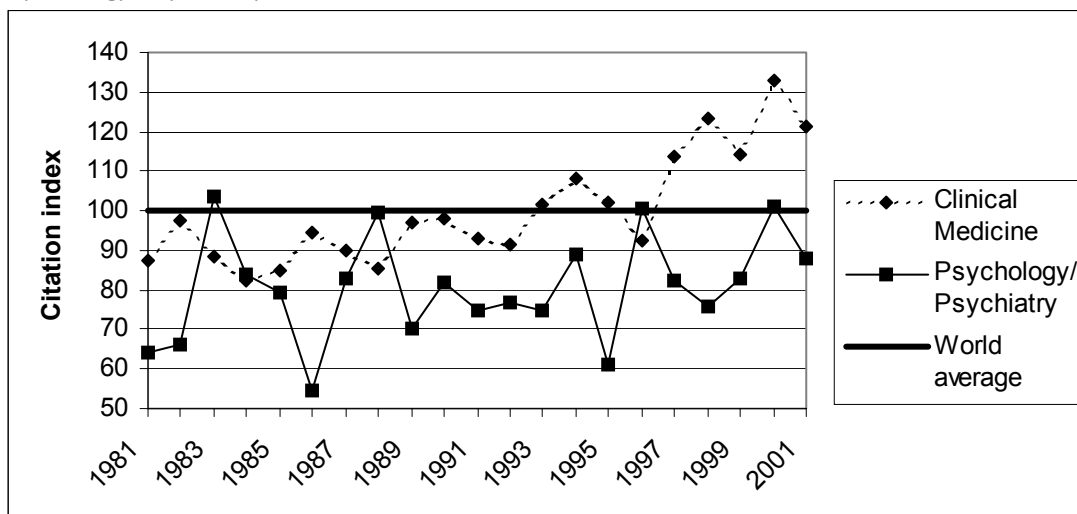
*Figure 2. Norwegian article production in Clinical Medicine and Psychology/Psychiatry, 1981-2002. Percent of world articles in the fields.**



*) Number of Norwegian articles divided by the sum of all countries' article production.
Source: NIFU/ISI (NSI).

In Figure 3 we have calculated citation indicators for Clinical Medicine and Psychology/Psychiatry for the period 1981-2001, based on accumulated citation counts up to and including 2002. As we can see, the scientific impact of the Norwegian articles in Clinical Medicine has been improving during the period. The last years the citation index has fluctuated at 120. That is, the articles have been cited 20% more than the world-average of the field. To the contrary, the articles published during the first 10 years were cited below the average. For Psychology/Psychiatry the indicator shows large annual variations. This is due to the small size of the field in which the presence or absence of a few highly cited papers may influence significantly on the citation mean. The general trend is, however, a citation rate significantly below the world average of the field.

Figure 3. Relative citation index for Norwegian articles in Clinical Medicine and Psychology/Psychiatry, 1981-2002.*

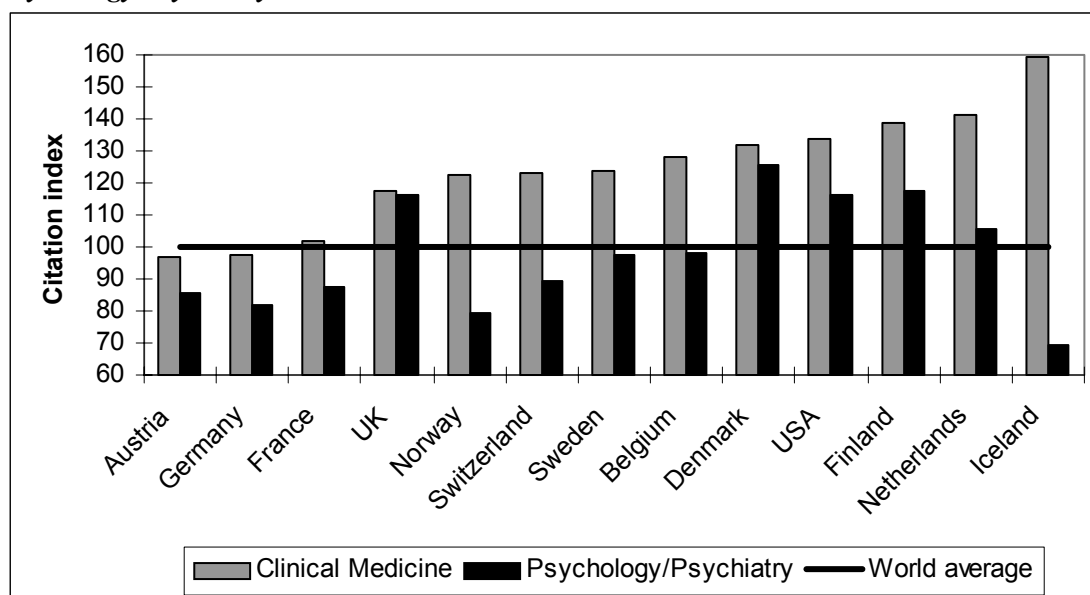


*) Based on annual publication windows and accumulated citations to these publications.

Source: NIFU/ISI (NSI).

For comparison we have also calculated the citation index for the USA and 12 other Northern European countries (Figure 4). Here we have used the last 5-year period as basis for the calculations (1998-2002). Despite the positive trend the last years, Norway only ranks as number 9 in Clinical Medicine. In Psychology/Psychiatry Norway ranks as number 12, only Iceland has a lower citation index.

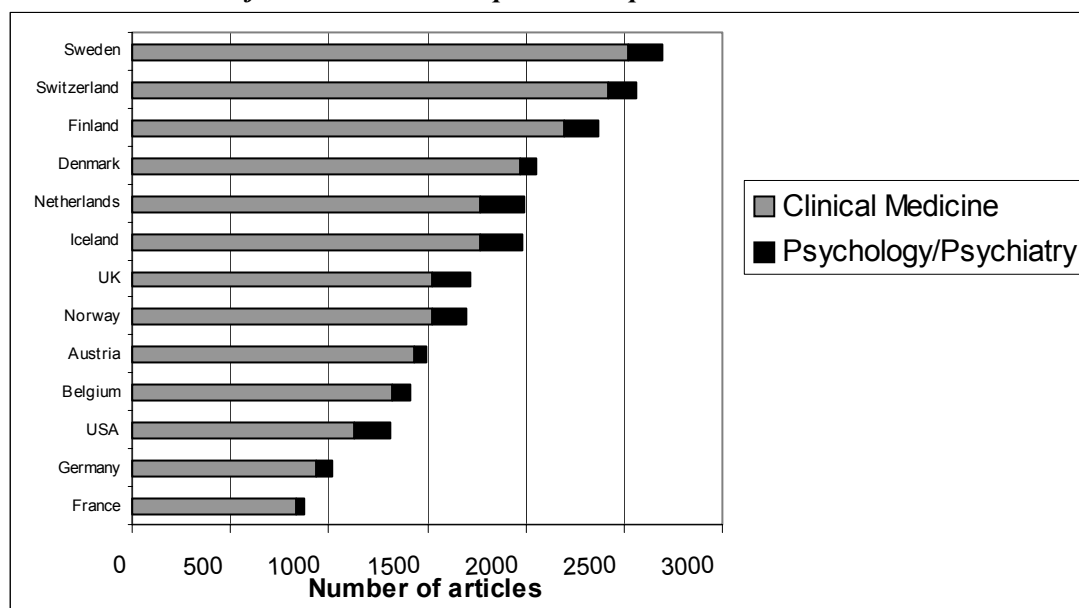
Figure 4. Relative citation index for selected countries, 1998-2002, Clinical Medicine and Psychology/Psychiatry.*



*) Based on the papers published during 1998-2002 and citation counts to those papers within the same 5-year window.
Source: NIFU/ISI (NSI).

In Figure 5 we have calculated the number of articles in the 5-year period 1998-2002 measured per capita for selected countries. Using this indicator Norway ranks as number 8.

Figure 5. Scientific publishing in Clinical Medicine and Psychology/Psychiatry for selected countries. Number of articles 1998-2002 per mill. capita.



Source: NIFU/ISI (NSI).

3.2 Scientific collaboration – bibliometric indicators

When scientists from different countries jointly produce a scientific article, this reflects the involvement of international collaboration. In this way, international co-authorships may be applied as an indicator of international scientific collaboration – particularly reflecting the collaborative structures of academic research.

There has been a significant increase in the number of internationally co-authored papers the last decades. Norway is no exception in this respect. Table 4 shows the collaboration patterns for Norway in Clinical Medicine and Psychology/Psychiatry for the period 1998-2002. In Clinical Medicine 40.4% of the articles were co-authored by researchers from other countries. In Psychology/Psychiatry the corresponding share was 31.5%. Thus, in both fields Norwegian researchers collaborate extensively with researchers from abroad. Sweden and the USA are the most important countries of collaboration. For example, 13.9% of the "Norwegian" articles in Clinical Medicine were co-authored by Swedish scientists.

Table 4. International co-authorships in "Norwegian" articles, 1998-2002. Most important countries, percent.

Clinical Medicine		Psychology/Psychiatry	
Country	% co-authored articles	Country	% co-authored articles
SWEDEN	13.9 %	US	11.8 %
US	11.3 %	SWEDEN	8.6 %
UK	7.9 %	DENMARK	5.6 %
DENMARK	6.8 %	FINLAND	5.6 %
FINLAND	5.1 %	NETHERLANDS	4.7 %
GERMANY	5.1 %	UK	4.5 %
NETHERLANDS	4.1 %	GERMANY	4.0 %
FRANCE	3.7 %	SWITZERLAND	2.3 %
ITALY	3.1 %	ITALY	1.8 %
CANADA	2.0 %	CANADA	1.7 %

Source: NIFU/ISI (NCR).

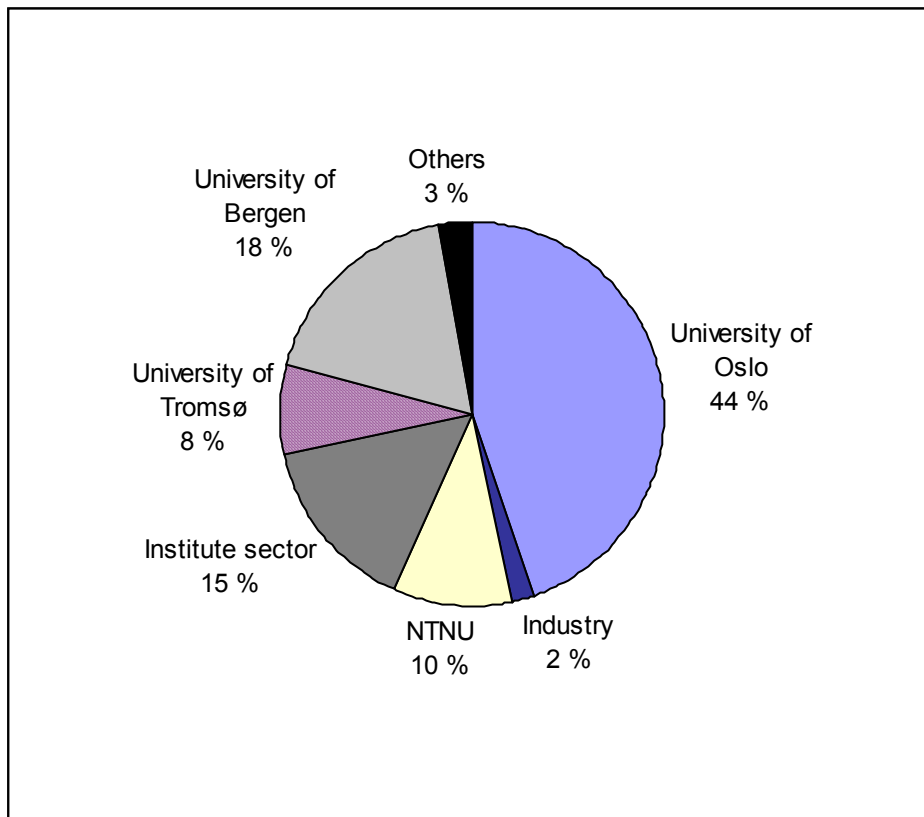
Because many articles have co-authors from more than two countries the sum of the shares is higher than the overall share international co-authorship.

3.3 Scientific publication in Norway – institutions

We have also calculated the number of articles by Norwegian universities/institutions, using the information available in the Address field of the articles. In this study we included articles from the 3-year period 1998-2000 (for the moment there are no data available for 2001 and 2002). In order to avoid multiple counting of articles we used fractionalised article counts (fractionalised for institutional co-authorship). By this method we identified 3087 articles in Clinical Medicine and 352 articles in Psychology/Psychiatry. The distribution of the articles is shown in Figure 7 and 8. It is important to be aware that

the university hospitals have been included in the university counts (other hospitals are included in the "Institute sector" category). Within the limit of this study it has not been possible to present counts for the individual hospitals.

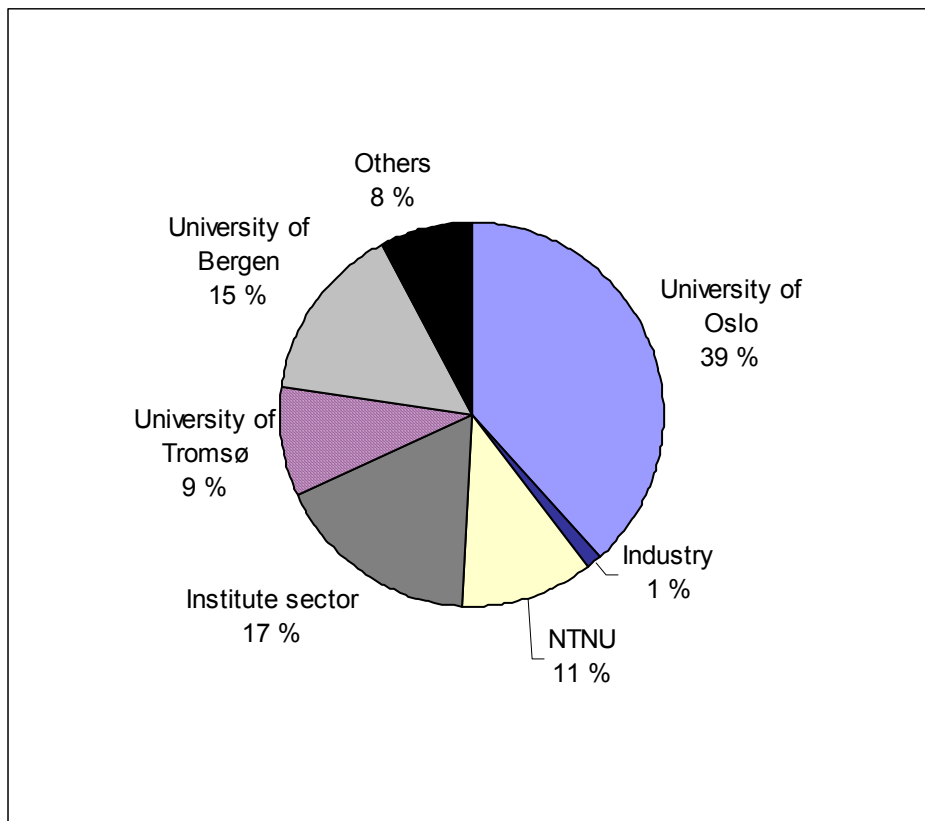
Figure 7. Clinical Medicine. Distribution of publications by institutions, 1998-2000, percent.



Source: NIFU/ISI (NCR).

University of Oslo accounts for the largest share of the Norwegian publications (44% in Clinical Medicine and 39% in Psychology/Psychiatry). The University of Bergen, NTNU, and the institute sector have a publication share in the range of 10-18%, both in Clinical Medicine and Psychology/Psychiatry. The industry sector only accounts for 1-2 percent of the scientific articles.

Figure 8. Psychology/Psychiatry. Distribution of publications by institutions, 1998-2000, percent.



Source: NIFU/ISI (NCR).

4 Bibliometric indicators of medicine – subfields

In this section we will present indicators for medical subfields/subdisciplines. The indicators cover the 5-year period 1998-2002. For each field we present indicators on the number of articles by Norwegian researchers, the share of world production in the field, and the relative citation index. The subfield classification system used is derived from Journal Performance Indicator (JPI) database (262 categories). From this database we selected the medical subfield categories, as well as categories partly covering medical research. For each of these categories we calculated world average publication and citation indicators for the 5-year period 1998-2002 (using bibliometric data on individual journals). From the database Nation Citation Report (NCR) we then calculated a corresponding set of indicators for the Norwegian articles. In this way the Norwegian performance could be compared with the world average.¹

4.1 Medical subfields – descriptions

In this section we present an overview of the different medical subfields selected, including a short description of the research covered by each of these categories.

Allergy

Allergy covers resources dealing with the full spectrum of immunologically-mediated hypersensitivity reactions including immediate or acute hypersensitivity, dermatitis, and asthma. This category also covers resources on the underlying cellular and molecular immunology specific to allergic reactivity, pathogenesis, tissue damage, clinical presentation, and modes of treatment.

Anatomy & Morphology

Anatomy & Morphology includes resources describing the characteristics, generation, and organization of structure in vertebrates or invertebrates. Topics cover embryology, developmental morphology, and functional anatomy, as well as specific structures, systems, or organisms.

Anesthesiology

Anesthesiology covers resources that focus on the administration of anesthetics, the treatment of pain, and the use of life support systems. This category also includes specific resources on cardiovascular anesthesia, pediatric anesthesia, and neurosurgical anesthesia.

Behavioral Sciences

Behavioral Sciences covers resources dealing with the biological correlates of observable action in humans or animals. These include sleep, aggression, sexual behavior, and learning as well as the various factors, natural or pharmacological, that alter such behaviors. Resources in this category cover neurobiology, experimental psychology, ethology, cognitive assessment, and behavioral consequences of neurological disorders.

Cardiac & Cardiovascular Systems

Cardiac & Cardiovascular Systems covers resources dealing with the diagnosis and treatment of heart disease. Coverage focuses on cardiac disease prevention, pharmacology, surgery, transplantation, and

¹ Sometimes journals were assigned to more than one subfield. In these cases we used average values. Also, a few papers were published in journals that had not assigned to a field category or in journals for which no citation data could be obtained. These papers were not included in the bibliometric analysis.

research. This category also includes cardiac testing, pacemakers, and medical devices. Resources focusing on circulation, hypertension, arterial disease, and stroke are placed in the PERIPHERAL VASCULAR DISEASE category.

Clinical Neurology

Clinical Neurology covers resources on all areas of clinical research and medical practice in neurology. The focus is on traditional neurological illnesses and diseases such as dementia, stroke, epilepsy, headache, multiple sclerosis, and movement disorders that have clinical and socio-economic importance. This category also includes resources on medical specialties such as pediatric neurology, neurosurgery, neuroradiology, pain management, and neuropsychiatry that affect neurological diagnosis and treatment.

Critical Care Medicine

Critical Care Medicine covers resources on healthcare specialties that focus on the care of patients with acute, life-threatening illness or injury. This category covers resources such as heart attack; poisoning; burns, pneumonia; surgical complications; premature birth; trauma including head trauma; stroke, and other neural injuries; intensive care anesthesia; and resuscitation.

Dentistry, Oral Surgery & Medicine

Dentistry, Oral Surgery & Medicine covers resources on the anatomy, physiology, biochemistry, and pathology of the teeth and oral cavity. This category includes specific resources on periodontal disease, dental implants, oral and maxillofacial surgery, oral pathology, and oral surgery. Coverage also includes resources on community dentistry, public health dentistry, and pediatric dentistry.

Dermatology & Venereal Diseases

Dermatology & Venereal Diseases covers resources on the anatomy, physiology, and pathology of the skin. It contains resources on investigative and experimental dermatology, contact dermatitis, dermatologic surgery, dermatologic pathology, dermatologic oncology, and venereal diseases. This category also includes specific resources on burns, wounds, and leprosy.

Emergency Medicine

Emergency Medicine covers resources on the science, education, and clinical practice of emergency medicine. Coverage spans the breadth of the specialty on trauma, pediatrics, toxicology, injury prevention and control, resuscitation, and emergency medical services.

Endocrinology & Metabolism

Endocrinology & Metabolism includes resources focused on endocrine glands; the regulation of cell, organ, and system function by the action of secreted hormones; the generation and chemical/biological properties of these substances; and the pathogenesis and treatment of disorders associated with either source or target organs. Specific areas covered include neuroendocrinology, reproductive endocrinology, pancreatic hormones and diabetes, regulation of bone formation and loss, and control of growth.

Gastroenterology & Hepatology

Gastroenterology & Hepatology covers resources on the anatomy, physiology, biochemistry, and pathology of the digestive system. This category includes specific resources on the prognosis and treatment of digestive diseases; stomach ulcers; metabolic, genetic, infectious and chemically induced diseases of the liver; colitis; and diseases of the rectum.

Geriatrics & Gerontology

Geriatrics & Gerontology covers resources on the aged and the aging process. This category includes the clinical, biochemical, histological, and psychological aspects of aging. Coverage also includes specific clinical problems in the treatment of elderly patients, as well as research on the cellular and animal correlates of age and senescence. Resources that focus on the psychological, social, and political aspects of aging are covered in the GERONTOLOGY category.

Gerontology

Gerontology covers resources that are concerned with the sociological and psychological issues of aging, including such areas as rehabilitation, aging and education, aging and work, aging and social policy as well as life span research. Geriatrics, which deals with the medical and clinical aspects of aging, is covered in the GERIATICS & GERONTOLOGY category.

Health Care Sciences & Services

Health Care Sciences & Services covers resources on health services, hospital administration, health care management, health care financing, health policy and planning, health economics, health education, history of medicine, and palliative care.

Health Policy & Services

Health Policy & Services covers resources on healthcare systems, including healthcare provision and management, financial analysis, healthcare ethics, health policy, and quality of care.

Hematology

Hematology covers resources that deal with blood and blood-forming tissues, as well as the functions, diseases, and treatments of these systems. Topics included are hemophilia, neoplastic disorders of the blood or lymphoid tissues, and mechanisms and disorders of thrombosis.

Immunology

Immunology covers resources dedicated to all aspects of immune response and regulation, at the cellular-molecular level as well as the clinical level. Other topics include studies of the interaction between pathogens and host immunity, as well as clinical immunology, emerging immunotherapies, and the immunologic contribution to disease course.

Infectious Diseases

Infectious Diseases covers resources on all aspects of the pathogenesis of clinically significant viral or bacterial diseases. This category is also concerned with resources on host-pathogen interactions, as well as the prevention, diagnosis, treatment, and epidemiology of disease.

Integrative & Complementary Medicine

Integrative & Complementary Medicine covers resources on the practical use of allopathic, alternative and/or complementary medicine and therapies in preventing and treating disease, healing illness, and promoting health. The category is concerned with resources on alternative systems of practice that provide for an overall rational and comprehensive approach to healthcare. Topics such as bioelectromagnetics applications; herbal medicine; diet, nutrition and lifestyle changes; manual healing methods; mind/body interventions; and pharmacological and biological treatment as well as any other unconventional health care practices are included in this category.

Medical Informatics

Medical Informatics covers resources on health care information in clinical studies and medical research. This category includes resources on the evaluation, assessment, and use of health care technology, its consequences for patients, and its impact on society.

Medical Laboratory Technology

Medical Laboratory Technology covers resources on the testing, methods, and equipment used in clinical, medical, hospital, and pathology laboratories, including clinical chemistry and biochemical analysis of laboratory samples. Resources on the development and refinement of the diagnostic technologies used in these laboratories are also covered.

Medicine, General & Internal

Medicine, General & Internal covers resources on medical specialties such as general medicine, family medicine, internal medicine, clinical physiology, pain management, and military and hospital medicine.

Medicine, Legal

Medicine, Legal covers resources on all aspects of medical legal issues, including government regulations and policies, malpractice, toxicological and pharmacological regulations, clinical therapeutic patents and other critical legal issues at the interface of law, medicine, and healthcare. The category also covers resources dealing with the various branches of forensic science.

Medicine, Research & Experimental

Medicine, Research & Experimental includes resources describing general medical research with a particular emphasis on extremely novel techniques and clinical interventions in a broad range of medical specializations and applications, including vaccine development, tissue replacement, immunotherapies, and other experimental therapeutic strategies. Resources in this category reflect clinical interventions that are in early stages of development, using in vitro or animal models, and small-scale clinical trials.

Microbiology

Microbiology includes resources dealing with all aspects of fundamental and applied studies of microorganisms, including bacteria, viruses, and fungi. This category also considers resources on the clinical aspects of the occurrence and treatment of microbial pathogens, basic science studies of microbial biochemistry and function, environmental microbiology, and bacterial/viral uses in biotechnology.

Neuroimaging

Neuroimaging covers resources on the mapping technologies used to treat, diagnose, or monitor brain lesions and mental disorders.

Neurosciences

Neurosciences covers resources on all areas of basic research on the brain, neural physiology, and function in health and disease. The areas of focus include neurotransmitters, neuropeptides, neurochemistry, neural development, and neural behavior. Coverage also includes resources in neuro-endocrine and neuro-immune systems, somatosensory system, motor system and sensory motor integration, autonomic system as well as diseases of the nervous system.

Nursing

Nursing covers resources on all aspects of nursing science and practice such as administration, economics, management, education, and technological applications as well as all clinical care specialties.

Nutrition & Dietetics

Nutrition & Dietetics covers resources concerning many aspects of nutrition, including general nutrition, nutrition and metabolism, nutrition science, clinical nutrition, vitamin research and nutritional biochemistry. Dietetics, the application of nutritional principles, is also included in this category.

Obstetrics & Gynecology

Obstetrics & Gynecology covers resources on the medical fields concerned with female reproductive function and reproductive organs. Obstetrics covers resources on pregnancy, fetal health, labor, and puerperium. Gynecology covers resources on the health and diseases of female sex organs and their impact on women's overall health. This category also includes resources on fertility, infertility, and contraception.

Oncology

Oncology covers resources on the mechanisms, causes, and treatments of cancer including environmental and genetic risk factors, and cellular and molecular carcinogenesis. Aspects of clinical oncology covered include surgical, radiological, chemical, and palliative care. This category is also concerned with resources on cancers of specific systems and organs.

Ophthalmology

Ophthalmology covers resources on the eye, its diseases, and refractive errors. Coverage includes research on the cornea, retina, and eye diseases. This category also includes resources on physiological optics and optometry as well as reconstructive surgery.

Orthopedics

Orthopedics covers resources on surgery and medical appliances as a means to preserve or restore function or alleviate pain in the musculoskeletal system, particularly the bones and joints.

Otorhinolaryngology

Otorhinolaryngology covers resources on the basic and clinical research and medicine of the ears, nose, and throat. This category also includes voice and audiology resources.

Pathology

Pathology includes resources specializing in the techniques, causes, and developmental effect of disease on living tissue. This category also considers the medical and biomedical applications of histological and cytogenetic methods, the development and use of novel techniques and diagnostic applications, and the pathologic study of specific tissues or diseases.

Pediatrics

Pediatrics covers resources on basic and clinical research in pediatrics. Numerous pediatric specialties are covered including, cardiology and respiratory systems, dentistry, dermatology, developmental behavior, gastroenterology, hematology, immunology and infectious diseases, neurology, nutrition, oncology,

psychiatry, surgery, tropical medicine, urology, and nephrology. Coverage also includes perinatology, neonatology, and adolescent medicine.

Peripheral Vascular Disease

Peripheral Vascular Disease covers resources on arterial occlusive disease (atherosclerosis or hardening of the arteries), venous obstruction and clotting, venous incompetence/insufficiency, cerebrovascular disease, aneurysms, vasospastic disorders, and other vascular disorders. This category also covers hypertension, circulation, and stroke. Resources on the diagnosis, treatment, and prevention of heart diseases are covered in the Cardiac & Cardiovascular Systems category.

Pharmacology & Pharmacy

Pharmacology & Pharmacy covers resources on the discovery and testing of bioactive substances, including animal research, clinical experience, delivery systems, and dispensing of drugs. This category also includes resources on the biochemistry, metabolism, and toxic or adverse effects of drugs.

Physiology

Physiology includes resources concerned with the normal and pathologic functioning of living cells, tissues, and organisms. Topics include comparative physiology, molecular biochemistry of cell function, applied physiology, and pharmacological intervention in pathophysiological processes.

Psychiatry

Psychiatry covers resources on clinical, therapeutic, research, and community aspects of human mental, emotional, and behavioral disorders.

Psychology, Applied

Psychology, Applied covers resources on organizational psychology, including selection, training, performance, and evaluation; organizational behavior; counseling and development; as well as aviation psychology and sports psychology.

Psychology, Biological

Psychology, Biological includes resources concerned with the biological basis of psychological states and processes. Biopsychology, psychophysiology, psychopharmacology, and comparative psychology resources are covered in this category.

Psychology, Clinical

Psychology, Clinical covers resources concerned with the combination of psychological therapy and clinical treatment such as behavior research and therapy, cognitive therapy, family therapy, marital and sexual therapy, psychotherapy, and rehabilitation psychology.

Psychology, Developmental

Psychology, Developmental covers resources concerned with the study of developmental changes in social and cognitive abilities. Key areas include adult development and aging, child and adolescent psychology, cognitive, perceptual, motor and language development as well as psychosocial and personality development.

Psychology, Educational

Psychology, Educational includes resources on educational psychology, educational measurement, creative behavior, instructional science, reading research, and school psychology.

Psychology, Experimental

Psychology, Experimental covers resources concerned with consciousness; cognition and memory; visual, auditory, and speech perception; and ecological psychology.

Psychology, Multidisciplinary

Psychology, Multidisciplinary covers resources with a general or interdisciplinary approach to the field. Resources on philosophical psychology, psychobiology, and the history of psychology are included in this category.

Psychology, Social

Psychology, Social covers resources on the behavior of the individual in a social context. Areas included are group processes, interpersonal processes, intercultural relations, personality, social roles, persuasion, compliance, conformity, sex roles, and sexual orientation.

Public, Environmental & Occupational Health

Public, Environmental & Occupational Health covers resources dealing with epidemiology, hygiene, and health; parasitic diseases and parasitology; tropical medicine; industrial medicine; occupational medicine; infection control; and preventive medicine. Also included are resources on environmental health; cancer causes and control; aviation, aerosol, and wilderness medicine.

Radiology, Nuclear Medicine & Medical Imaging

Radiology, Nuclear Medicine & Medical Imaging covers resources on radiation research in biology and biophysics. Resources in this category focus on interventional radiology, investigative radiology, neuroradiology, radiotherapy, and oncology. Nuclear Medicine resources are concerned with the diagnostic, therapeutic, and investigative use of radionuclides. Medical Imaging resources are concerned with computerized medical imaging and graphics.

Rehabilitation

Rehabilitation covers resources on therapy to aid in the recovery or enhancement of physical, cognitive, or social abilities diminished by birth defect, disease, injury, or aging.

Respiratory System

Respiratory System covers resources on all aspects of respiratory and lung diseases, including their relation to cardiovascular and thoracic surgery and diseases.

Rheumatology

Rheumatology covers resources on clinical, therapeutic, and laboratory research about arthritis and rheumatism, the chronic degenerative autoimmune inflammatory diseases that primarily affect joints and connective tissue.

Substance Abuse

Substance Abuse covers resources on the behavior, education, treatment, and research of alcohol, drug, and other substances of addiction.

Surgery

Surgery covers resources on general surgical topics including the different types of surgery (cardiovascular, neurosurgery, orthopedic, pediatric, or vascular); allied disciplines of surgery (surgical oncology, pathology, or radiology); and surgical techniques (arthroscopy, microscopy, or endoscopy).

Transplantation

Transplantation covers resources that focus on the assimilation of grafted tissue and the reconstitution of removed organs or parts of organs. The coverage focuses on transplantation procedures and the maintenance of transplanted tissues or organs. Specific transplantation coverage focuses on heart, lung, kidney, and bone marrow.

Tropical Medicine

Tropical Medicine covers resources on the study and treatment of disease, parasites, and other medical conditions unique to or originating in tropical regions.

Urology & Nephrology

Urology & Nephrology covers resources on the diagnosis and treatment of diseases of the genitourinary tract and kidneys. This category includes general urology and nephrology as well as specialty resources on the prostate, dialysis and other blood purification techniques, transplantation, and renal failure.

Virology

Virology includes resources dealing with all aspects of viral organisms and host-virus interactions. Resources in this category cover the molecular, biochemical, and cellular studies of plant-, animal-, and human-specific viruses, as well as bacteriophages. This category also contains materials on medical virology and pathogenesis and treatment of viral diseases.

4.2 Medical subfields – indicators

In Table 5 we have listed different bibliometric indicators for subfields within clinical medicine. One indicator is the number of publications by Norwegian researchers in the 5-year period 1998-2002. The largest subfield is Oncology with a production of 831 articles during this period. Immunology and Microbiology represent the second and third largest subfields in terms of production of papers (790 and 558, respectively), although these fields only partly cover clinical research. Next come Neurosciences (512) and Pharmacology & Pharmacy (457).

Since the size of the subfields depends on how many journals that are assigned to each of them, it may be more interesting to compare the Norwegian production with the world total of the subfields. As we have seen, Norway on average contributes to 0.55% of the world's article production. Thus the "expected" share is 0.55% and a higher or lower share means that Norway has a positive or negative specialisation respectively.

One point to notice is that Norway has strong specialisation in Oncology. The share in this discipline covering basic as well as applied and clinical cancer research is 1.1%. This means that the production of Norwegian papers is 100 % higher (400 articles) than "expected". Another large field with a strong Norwegian specialisation is Immunology. Here the production is more than 300 articles higher than what would be expected compared to the average. Among the fields of medium size the specialisation is particularly strong in Rheumatology; Dentistry, Oral Surgery & Medicine; Obstetrics & Gynecology; and Pathology.

Relatively few clinical fields show a negative specialisation. This is not unexpected since Norway shows a positive overall specialisation in Clinical Medicine (0.7%), as we have seen. In fact, all the fields with a share significantly lower than the Norwegian average (0.55%) are small, with a production of less than 100 publications during the 5-year period.

The citation rates of the fields vary considerably. By far, the highest citation index is obtained in Medicine, General & Internal. In this field covering a mixture of different medical research the Norwegian articles are cited 230% more than the world average. Norway also has a very high citation rate in Allergy, Ergonomics, Gerontology, Medical Laboratory Technology, Transplantation, and Urology & Nephrology. In these fields the citation rate is in the range of 46 to 81% above the world-average. Next come Clinical Neurology, Dermatology & Venereal Diseases, Geriatrics & Gerontology, Nutrition & Dietetics, Pediatrics and Surgery all with a citation rate 20-30% above the world-average.

The lowest citation rate is found in Ophthalmology. In this field the articles only obtain 65% of the world-average citation rate of the field. Also in the fields Otorhinolaryngology, Substance Abuse, and Neuroimaging the citation rates are very low, 20-30% below the world-average. Despite a large production and a strong specialisation in Immunology, Norway is cited significantly lower than the world average in this field. In the fields Endocrinology & Metabolism, Hematology, Infectious Diseases, Medicine Research & Experimental, Physiology, Radiology, Nuclear Medicine & Medical Imaging, Rheumatology and Virology the articles are cited 10-20% below in world-average.

Table 5. Bibliometric indicators for subfields within clinical medicine, Norway 1998-2002.*

Subfield	Number of Norwegian articles	Relative citation index (world average = 100)	Share of world production in field
ALLERGY	68	165	0.8 %
ANATOMY & MORPHOLOGY	28	116	0.4 %
ANESTHESIOLOGY	123	112	1.0 %
CARDIAC & CARDIOVASCULAR SYSTEMS	420	113	0.8 %
CLINICAL NEUROLOGY	384	120	0.8 %
CRITICAL CARE MEDICINE	65	106	0.6 %
DENTISTRY, ORAL SURGERY & MEDICINE	313	109	1.6 %
DERMATOLOGY & VENEREAL DISEASES	68	124	0.3 %
EMERGENCY MEDICINE	22	113	0.8 %
ENDOCRINOLOGY & METABOLISM	299	87	0.6 %
ERGONOMICS	47	177	1.6 %
GASTROENTEROLOGY & HEPATOLOGY	242	119	0.8 %
GERIATRICS & GERONTOLOGY	30	127	0.4 %
GERONTOLOGY	23	149	0.3 %
HEMATOLOGY	357	85	0.9 %
IMMUNOLOGY	790	82	0.9 %
INFECTIOUS DISEASES	264	88	0.9 %
MEDICAL INFORMATICS	46	107	0.9 %
MEDICAL LABORATORY TECHNOLOGY	55	181	0.7 %
MEDICINE, GENERAL & INTERNAL	267	331	0.5 %
MEDICINE, RESEARCH & EXPERIMENTAL	233	86	0.6 %
MICROBIOLOGY	558	92	1.0 %
NEUROIMAGING	19	74	0.4 %
NEUROSCIENCES	512	104	0.5 %
NUTRITION & DIETETICS	180	124	0.9 %
OBSTETRICS & GYNECOLOGY	299	112	1.1 %
ONCOLOGY	831	101	1.1 %
OPHTHALMOLOGY	82	65	0.3 %
ORTHOPEDICS	124	118	1.1 %
OTORHINOLARYNGOLOGY	90	76	0.6 %
PATHOLOGY	306	100	1.1 %
PEDIATRICS	289	127	0.8 %
PERIPHERAL VASCULAR DISEASE	322	103	1.0 %
PHARMACOLOGY & PHARMACY	457	91	0.5 %
PHYSIOLOGY	376	87	0.9 %
RADIOLOGY, NUCLEAR MEDICINE & MEDICAL IMAGING	320	86	0.7 %
RESPIRATORY SYSTEM	167	114	0.6 %
RHEUMATOLOGY	176	87	1.7 %
SUBSTANCE ABUSE	69	78	0.7 %
SURGERY	396	121	0.5 %
TRANSPLANTATION	118	153	0.6 %
TROPICAL MEDICINE	18	98	0.3 %
UROLOGY & NEPHROLOGY	154	146	0.5 %
VIROLOGY	92	89	0.4 %

*) Based on the papers published during 1998-2002 and citation counts to those papers within the same 5-year window. Subfields with less than 10 articles have been excluded from the table.
Source: NIFU/ISI (JPI/NCR).

In Table 6 we have calculated a similar set of indicators for subfields within psychology/psychiatry and public health. The largest field in terms of number of papers is Psychiatry with a production of more than 400 papers during this 5-year period. This corresponds to 0.7% of the world-production of the field (i.e. a positive specialisation). Nevertheless, the impact is very low and the articles are cited 29% below the world average. For the subfields within psychology we find a diversified picture. For most of them we find a positive specialisation. That is, the publication share of the fields is higher than what is the overall average for Norway (0.55%). The citation impact in the subfields covering the biological basis of human actions: Behavioral Sciences and Psychology, Biological is higher than the world-average (index: 109-112). In Psychology, Developmental and Psychology, Applied the citation index is also above the world average. In contrast the citation rate is very low in the subfield covering behaviour in a social context: Psychology, Social. In this field the articles only obtained 55% as many citations as the world average. Norway has a high publication share in the field covering a general or interdisciplinary research - Psychology, Multidisciplinary. But in this field the articles are poorly cited (index: 63). The citation index is slightly higher in Psychology, Clinical (82), but still significantly lower than the world average.

Norway has a very strong positive specialisation in public health and contributes to 1.2% of the world production in the field Public, Environmental & Occupational Health. In total more than 580 articles were produced by Norwegian researchers during the period 1998-2002. The citation index is also good (116). Also in the related subfield Health Care Sciences & Services we find a strong positive specialisation and a citation index above average (110). The citation index is also high in Health Policy & Services (117). In the field Medical, Legal dealing with medical legal issues, the articles are very highly cited – 71% above the world-average. This is however, a rather small field in terms of number of articles. Norway also shows a positive specialisation in Nursing and the production of almost 100 papers represented 0.8% of the world production in this field. In this subfield the articles are cited 9% above the world-average (index: 109).

Table 6. Bibliometric indicators for subfields within psychology/psychiatry and public health, Norway 1998-2002.*

Subfield	Number of Norwegian articles	Relative citation index (world average = 100)	Share of world production in field
BEHAVIORAL SCIENCES	131	109	0.9 %
HEALTH CARE SCIENCES & SERVICES	94	110	1.1 %
HEALTH POLICY & SERVICES	55	117	0.6 %
MEDICINE, LEGAL	50	171	0.8 %
NURSING	98	109	0.9 %
PSYCHIATRY	405	71	0.7 %
PSYCHOLOGY, APPLIED	33	131	0.4 %
PSYCHOLOGY, BIOLOGICAL	26	112	0.6 %
PSYCHOLOGY, CLINICAL	98	82	0.5 %
PSYCHOLOGY, DEVELOPMENTAL	70	105	0.7 %
PSYCHOLOGY, EDUCATIONAL	34	67	0.7 %
PSYCHOLOGY, EXPERIMENTAL	76	92	0.5 %
PSYCHOLOGY, MULTIDISCIPLINARY	204	63	1.0 %
PSYCHOLOGY, SOCIAL	51	55	0.5 %
PUBLIC, ENVIRONMENTAL & OCCUPATIONAL HEALTH	585	116	1.2 %
REHABILITATION	51	99	0.4 %

*) Based on the papers published during 1998-2002 and citation counts to those papers within the same 5-year window. Subfields with less than 10 articles have been excluded from the table.

Source: NIFU/ISI (JPI/NCR).

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