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Publishing patterns in Pharmacy

A bibliometric analysis of publications from six Nordic universities

Abstract

Pharmacy is a multidisciplinary research field that combines natural sciences, health sciences and social sciences to study drugs and pharmaceutical preparations from multiple perspectives. The study explores publishing patterns in pharmacy via bibliometric methods, that is statistical methods applied to study scientific literature. Earlier bibliometric studies focusing on pharmacy have used data from the international citation databases Web of Science and Scopus. In most of these studies, pharmacy has been operationalized by focusing on journals categorized as pharmacy journals. This study provides a new approach to the study of publishing patterns, by using data from institutional Current Research Information Systems (CRIS), and by using pharmacy organizations as the basis of operationalization of pharmacy. It seeks to provide a more comprehensive picture of publishing patterns, since the data covers all publication types used in pharmacy and is not limited to pharmacy journals. The objective of this study is thus to explore whether the selection of databases and operationalization of the discipline affects the results concerning publishing patterns in pharmacy. The results obtained in this study are very similar to earlier studies utilizing international databases. However, the results show that pharmacy researchers also publish in national languages, and that there are several national journals amongst the core journals that are not covered by the international databases. The multidisciplinary nature of pharmacy can be seen in the wide range of journals in which pharmacy researchers publish their articles.

Keywords: pharmacy, publishing patterns, bibliometrics, current research information systems, journals, multidisciplinarity

Introduction

Pharmacy is a multidisciplinary research field that combines natural sciences, health sciences and social sciences to study drugs and pharmaceutical preparations from multiple perspectives. There are several subdisciplines in pharmacy, including biopharmaceutics, pharmacology, pharmaceutical biology, pharmaceutical chemistry, pharmaceutical technology, industrial pharmacy, and social pharmacy.

This study explores publishing patterns in pharmacy via bibliometric methods, that is statistical methods applied to study scientific literature. In bibliometric research, publishing patterns of a discipline are typically studied via analysing the typicality of publication types, the language of publications, the number of authors, the number of references and citations, the selection of publication channels as well as the number of publications by authors in a given time period.

There are several reasons why studying disciplinary publishing patterns is important. Publications are the major outputs of scientific work, and can reveal disciplinary structures, working practices within disciplines and audiences of the research (Kyvik, 1991; Whitley, 2000). The number of authors indicates whether the work is done in groups or alone. The language of publications and typical publication channels tell us about the degree to which the research is internationally or nationally oriented. The selection of journals and the subject field of journals conveys what other disciplines are close to the discipline, and the degree to which the discipline is multidisciplinary. The distribution of research articles into journals from different fields reveals internal structures of the discipline.

Studying publishing patterns is important also because in research evaluations the number of publications and citations are typically used as a means to evaluate scientific impact. It is widely recognized that differences between disciplines should be taken into consideration when using bibliometric indicators as evaluation tools. For example, in natural and medical sciences, publishing concentrates heavily on international scientific journals, whereas in social sciences and humanities, publishing monographs and using national publication channels has been more typical (Kyvik, 1991; Piro, 2013; Puuska, 2014). The better we recognize the differences in publication patterns, the more valid are the evaluations.

The first step in bibliometric studies is the extraction of the relevant literature to form a corpus of data, to answer the research questions (Zitt el al., 2019). The databases used, and how the discipline is operationalized, are central issues in the compilation of the relevant data.

The most frequently used databases in bibliometric studies are the international citation databases Web of Science and Scopus. These databases concentrate on international scientific publications, and thus, other publication types, like articles in national scientific journals or book chapters, may not be included in the dataset due to the selection criteria of the international databases. Current Research Information Systems (CRIS) have a better coverage of these publication types (Sivertsen, 2019). CRIS are databases to which an organization (or organizations) collects information about research activities, particularly publications, of the researchers affiliated with the organization.

Another central choice in bibliometric studies is how the discipline is operationalized. A discipline can be defined from different starting points, for example, with the help of general science classification schemes or from an organizational point of view (Hammarfelt, 2018; Zitt et al., 2019). A well-known science classification scheme is OECD's Field of Science and Technology Classification (OECD, 2015). The international citation databases Web of Science and Scopus have their own subject classifications. The Web of Science Subject classification has 254 different subject categories, for example,

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"Pharmacology & Pharmacy" (Web of Science, 2021). All journals covered in Web of Science are categorized into one or more subject categories. These different operationalization methods have their own advantages and limitations (Zitt et al., 2019). When a discipline is delineated using journal sets compiled using predefined subject categories, for example Web of Science "Pharmacy and Pharmacology", publications that pharmacy researchers have published in journals belonging to other categories are left out. On the other hand, if organizational structures such as faculties or departments are the basis of the selection of data, the pharmacy publications by researchers from other organizations are left out of the data.

Earlier bibliometric studies on pharmacy have used data from Web of Science and Scopus (AL-Ageel et al., 2020; Barrett et al., 2016; Dotson et al., 2011; Mendes et al., 2019; Minguet et al., 2017; Nasir et al., 2015; Sweileh et al., 2014; Thompson, 2018, Weathers & Unni, 2018). In most of these studies, pharmacy has been delineated by focusing on journals categorized as pharmacy journals. This study applies a novel approach by compiling data from institutional CRIS and by operationalizing pharmacy by using pharmacy organizations as the starting point.

The first objective of this study is to explore whether and how the selection of databases and operationalization of the discipline affect the results concerning publishing patterns in pharmacy. The second objective is to explore whether and how the multidisciplinary nature of pharmacy research manifests itself in publishing patterns.

The objectives are approached by studying the qualities of publications and journals. The questions concerning the qualities of the publications are the following:

1) What is the distribution of different publication types?
2) In what languages are the publications written?
3) What is the number of co-authors of the publications?

The questions concerning journals are the following:

4) Which subject categories do the journals belong to?
5) What is the number of journals in which pharmacy researchers publish?
6) How are the articles distributed between different journals?
7) What are the key journals?

Literature review
Earlier bibliometric studies of publishing patterns in pharmacy have been conducted mainly from two different starting points: the first group of studies has explored publication patterns at the level of disciplinary groups, and the second group of studies has focused solely on pharmacy.

In the first group of studies, pharmacy has been included in the medicine and health sciences disciplinary group (Piro, 2013; Puuska, 2014). Disciplinary groupings typically used in these studies are humanities, social sciences, medicine and health sciences, natural sciences, engineering and technology, and agricultural sciences. This delineation of disciplines is based on OECD's Field of Science and Technology Classification (OECD, 2015). The strength of this approach is that it gives us a broad view of publication patterns across different disciplinary groups. Piro (2013) and Puuska (2014) used national CRIS-databases as the source of data in their studies and found major differences in the publishing patterns of different disciplinary groups. Journal articles were the most common publication type in medicine and health sciences and natural sciences, while the proportion of other

publication types was marginal. In humanities and social sciences, the shares of journal articles, book articles and monographs were more evenly distributed. The number of co-authors was considerably bigger in medicine and health sciences and natural sciences compared to social sciences and humanities.

Both Piro's (2013) and Puuska's (2014) studies included data from only one country. Data covering only one country can give nationally focused results due to national research emphasis. In addition, using large disciplinary groups can be a problem because there can be differences in the publishing patterns between individual disciplines that are included in the larger disciplinary group. There can also be differences in publishing patterns between the subdisciplines of a specific discipline (Fry & Talja, 2004). These differences cannot be taken into account in the disciplinary group level analyses.

The second group of studies focuses solely on pharmacy and typically uses data from Web of Science and Scopus. These studies have explored different aspects of publishing patterns in pharmacy or its subdisciplines, for example: publishing productivity (Thompson, 2019; Weathers & Unni, 2018), degrees of international collaboration (AL-Ageel et al., 2020), changes in number of authors per article in pharmacy journals over time (Dotson et al., 2011), publishing patterns in pharmacy subdisciplines or subject areas (Sweileh et al., 2014; Sweileh et al., 2018), and research carried out by researchers from a specific geographic area (Nasir et al., 2015; Sweileh et al., 2014; Thompson, 2018). The Web of Science classification of pharmacy journals has been studied (Minguet et al., 2017) as well as other methods for mapping pharmacy journals (Barrett et al., 2016; Mendes et al., 2019).

In most of these studies, the starting point of data collection and delineating the discipline has been journal sets. Studied pharmacy journal sets have mainly been identified by using journal classifications of databases and by selecting articles published in journals classified to the Web of Science subject category "Pharmacology & Pharmacy" (Minguet et al., 2017; Nasir et al., 2015; Thompson, 2018). Other selection methods include using a lexical analysis of articles published in journals which have pharmacy related words in journal titles (AL-Ageel et al., 2020; Mendes et al., 2019), using keyword searches to identify pharmacy publications (Sweileh et al., 2014), combining the journal set based approach to the keyword search based approach (Sweileh et al., 2018), selecting a small number of journals based on the specific criteria such as journal impact and clinical orientation (Dotson et al., 2011) or selecting journals included in pharmacy core journal lists (Barrett et al., 2016). Data have also been extracted by using organizations, for example pharmacy departments and schools as a starting point (Thompson, 2019; Weathers & Unni, 2018).

These earlier studies have shown that peer-reviewed academic journal articles are the main publication type within pharmacy (Weathers & Unni, 2018), as well as the most cited publication type (Barrett et al., 2016), and that articles are usually co-authored (Dotson et al., 2011; Sweileh et al., 2018). Like many bibliometric studies (van Raan, 2019) these studies have found that distributions related to publishing patterns are skewed. A small number of researchers or institutions publish most of the articles (Thompson, 2019; Thompson, 2018; Weathers & Unni, 2018), a small number of core journals receive most of the citations (Barrett et al., 2016), and the majority of articles are published in a small number of journals (Sweileh et al., 2018). These studies have also shown that publishing patterns are not stable but change over time. The number of publications published by pharmacy researchers (Weathers & Unni, 2018) or within specific pharmacy subject areas (Nasir et al., 2015; Sweileh et al., 2018) have increased over the years, as well as the number of authors per article (Dotson et al., 2011; Sweileh et al., 2018). Pharmacy researchers cite literature from many disciplines outside pharmacy, especially medicine and natural sciences (Barrett et al., 2016). Pharmacy journals are considered a heterogeneous group of journals (Mendes et al., 2019; Minguet et al., 2017).

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International pharmacy journals are the most important publication channels, but national journals are also used (Nasir et al., 2015; Sweileh et al., 2014) and considered important (Barrett et al., 2016).

In the aforementioned studies, the research data consist mainly of international scientific articles. Thus, other publication types, like articles in national scientific journals or book chapters, are usually not included in the datasets due to the publication selection criteria of the international databases. This study contributes to this gap in knowledge.

Next, research methods and data used in this study are presented, followed by research results, discussion, and conclusions.

Methods
To answer the research questions, publication data from years 2011-2016 of six Nordic universities' pharmacy units were collected from the national CRIS (Norway and Finland) and from the universities' own CRIS (Sweden and Denmark).

CRIS are databases to which an organization or organizations collect information about research activities, particularly publications, of the researchers affiliated with the organization (Sivertsen, 2019). Information about research activities and background information about researchers, such as institutional affiliations, can be manually added to the system or imported from other administrative systems of the organization. The collected information can be used for example in research evaluation, funding decisions or for management purposes. CRIS databases can operate on a national or institutional level. There are also solutions where these two approaches are combined; data are collected to the organizational CRIS databases first and then imported to the national CRIS.

CRIS databases typically focus on scientific publications of a single organization (Sivertsen, 2019). International scientific articles, articles in national scientific journals, conference articles, book chapters and books are covered by these databases. In addition to scientific publications, CRIS databases may contain information about other publication types, including publications aimed for professional and lay audiences (such as newspaper articles) and publications in different languages. A more comprehensive picture of publishing patterns may be gained by collecting data from CRIS databases compared with Web of Science and Scopus, because CRIS databases include a larger range of publication types.

Publication metadata is either manually added to the CRIS databases by individual researchers or imported from international databases (Sivertsen, 2019). An important step in data registration is the verification of publications. This is usually done by libraries or administrative personnel.

One important component of CRIS databases is that they contain information about organizational structures of universities and institutions. Publications are linked to researcher profiles which include information about organizational affiliations. The organizational information makes it possible to create datasets that are based on affiliations such as faculty, department, or research group. Department- or faculty-based datasets are more difficult to create in international databases. In international databases, publications of a specific department or faculty can be retrieved by using keyword searches, but due to variations in the affiliation notations, such as missing information about the department, some of the relevant publications are not found. The search results may also contain other organizations' publications because the address notations include the words used in the search.

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The multiorganizational approach in this study was selected in order to build a large enough dataset, so that valid conclusions could be made. Using publication data from six universities gives a broader view of pharmacy publishing patterns and reduces the potential effects of the special characteristics of individual institutions on the results.

The studied pharmacy faculties and departments, the names of the CRIS databases and the number of publications in the data are presented in Table 1.

Pharmacy organization	Country	CRIS	Number of publications
Department of Pharmacy, Faculty of Mathematics and Natural Sciences, University of Oslo	Norway	Cristin	768
Department of Pharmacy, Faculty of Health Sciences, University of Tromso	Norway	Cristin	280
Faculty of Pharmacy, University of Helsinki	Finland	Virta	1155
School of Pharmacy, Faculty of Health Sciences, University of Eastern Finland	Finland	Virta	1264
Faculty of Pharmacy (2011), Department of Pharmacy and Department of Drug Design and Pharmacology (2012-2016), Faculty of Health and Medical Sciences, University of Copenhagen	Denmark	CRIS-database of University of Copenhagen	3011
Faculty of Pharmacy, University of Uppsala	Sweden	Diva	1749
Total			Total number of publications 8227

Table 1. The organizations selected to the study, the CRIS databases used and the number of publications 2011-2016.

The criteria for selecting the university units for the study were the following: 1) the unit is a pharmacy department or faculty, that 2) functions within a university setting, and 3) the publication data are available. The original mapping of suitable units was done by going through the Nordic universities' webpages. The Nordic countries were selected as a starting point, as university systems in Nordic countries have many common features. Six units were selected (see Table 1). The largest pharmacy departments and faculties from Denmark, Finland, Norway, and Sweden are included in the study.[1] The availability of publication data from the selected units was confirmed. The data about the publications of pharmacy faculties and departments were available in all the CRIS databases from year 2011, therefore this year was selected as the starting point. Consent to using the data for research purposes was received from the organizations responsible for the gathering of publication data.

Most of the departments and faculties selected for this study describe their research as interdisciplinary or multidisciplinary (UiT The Arctic university of Norway, 2021; University of Copenhagen, 2021a; University of Copenhagen, 2021b; University of Eastern Finland, 2021; University of Helsinki, 2021; University of Oslo, 2021; Uppsala University, 2021). All the departments and faculties under analysis are research oriented. Research in these departments and faculties is done in research groups, which are organized either around departments, by the subdisciplines of pharmacy, or by research subject. Internationality is mentioned in many descriptions of the units as well as the importance of a national perspective. Industry and society are named as important stakeholders and collaborators. All the studied departments offer bachelors', masters', and doctoral degrees.

The research data consist of bibliographic information of 8227 publications. The data extracted from the CRIS databases had to be unified before the analysis. The unification of research data was the most time-consuming phase of this research. All data preparation - and analysis - was made with Excel and SPSS.

CRIS databases have variation in their classification of publication types. A new classification was therefore created, and different systems' publication classifications were mapped to this new classification in order to have comparable data from different databases. The new classification included the following publication types: "Academic article in a peer-reviewed journal", "Academic literary review in a peer-reviewed journal", "Academic book"," Academic book chapter", "Conference article or abstract", "Doctoral dissertation", "Report", "Popular scientific article, Newspaper article" and "Article in trade journal or book".

The names of the journals were disambiguated. Different name variants were used in different datasets for some journals, for example for "The Journal of the American Medical Association" also variants "Jama" and "J A M A" were used. One of the name variants was selected as primary and the other name variants were unified to that. Notations of publication languages were also harmonized. The Web of Science journal classification was added to those publications for which it was available. The Web of Science classification was selected because it is also used in the Journal Citation Reports, which is the source of impact factors, used widely in the evaluation of scientific journals.

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1 There are other pharmacy units in the Nordic countries but these were not included in this study for the following reasons: the unit was small in terms of the number of publications, the publications of the unit were difficult to extract because pharmacy was only one of the disciplines within the unit (for example "Department of Physics, Chemistry and Pharmacy"), the unit focused solely on pharmacy teaching or represented only one specific specialty within pharmacy.

Results

Distribution of publication types

The most typical (80.9%) publication type aimed for an academic audience was "Academic article in a peer-reviewed journal". "Academic literary review in a peer-reviewed journal" was the next most common publication type, with a 4.9% share.

Other publication types aimed for an academic audience – "Conference articles or abstracts", "Academic books", "Academic book chapters", and "Doctoral dissertations" comprised 10.4% of all publications. Of these, shorter publications: "Conference articles or abstracts" (4.3%) and "Academic book chapters" (3.0%) were more common. The share of the "Academic books" was only 0.4% of all publications. "Doctoral dissertations" formed 2.7% of the publications. "Doctoral dissertations" are special kinds of publications because of their once-only nature.

Publications aimed for other audiences, such as practical professionals, decision makers and the general public formed 3.8% of the publications: 2.3 % of the publications were "Articles in trade journals or books", 0.5% were "Reports" and 1.0 % "Popular scientific articles and newspaper articles".

Most of the publications, 92.4%, were written in English and 7.4% in national languages. Typically, publications aimed for an academic audience were written in English, while publications aimed for other audiences were more often written using national languages. Distribution of publication types and languages is presented in the Table 2.

Publication type	English	National	Other	All languages
Academic article in a peer-reviewed journal	6430	216	9	6655
	78,2%	2,6%	0,1%	80,9%
Academic literary review in a peer-reviewed journal	353	47	2	402
	4,3%	0,6%	0,0%	4,9%
Conference article or abstract	341	16	0	357
	4,1%	0,2%	0,0%	4,3%
Academic book	24	11	0	35
	0,3%	0,1%	0,0%	0,4%
Academic Book Chapter	203	42	0	245
	2,5%	0,5%	0,0%	3,0%
Doctoral dissertation	215	4	0	219
	2,6%	0,0%	0,0%	2,7%
Report	9	31	0	40
	0,1%	0,4%	0,0%	0,5%
Article in trade journal or book	23	164	3	190
	0,3%	2,0%	0,0%	2,3%
Popular scientific article, newspaper article	6	76	2	84
	0,1%	0,9%	0,0%	1,0%
All publication types	7604	607	16	8227
	92,4%	7,4%	0,2%	100,0%

Table 2. Publications of the pharmacy faculties and departments 2011-2016: frequency of publication types and publication languages. Percentages are counted from the total number of publications (n=8227).

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These results are in line with Piro's (2013) and Puuska's (2014) result: in the medical and health sciences disciplinary group, the most common publication type is article in a peer-reviewed international journal. Other similarities in these studies and the present study are that book chapters/articles were also published, but much less than articles in journals, and that monographs were the least typical publication type.

Number of authors

Publications aimed for an academic audience were mainly co-authored (Table 3). In the publication type "Academic article in a peer-reviewed journal" the mean number of authors was 7 per article. Fifty percent of articles were published by groups of 4-8 researchers. The publication types "Academic literary reviews in peer-reviewed journals" and "Conference articles or abstracts" were published in somewhat smaller groups, as the mean number of authors was 5. Fifty percent of the "Academic literary reviews in peer-reviewed journals" were published in groups of 2-6 researchers. "Academic books" and "Academic book chapters" were written by smaller groups than academic articles. The mean number of authors in both categories was 3. Fifty percent of the "Academic books" and "Academic book chapters" were written by groups of 2-4 researchers.

Publications aimed for other audiences were written by smaller groups or by one researcher. The mean number of authors in "Reports" was 5. Fifty percent of the "Reports" were published by 2-7 researchers. "Articles in trade journals" and "Popular articles and newspaper articles" were typically written by 1-2 authors. The mean number of authors in "Articles in trade journal or a book" and "Popular scientific article, newspaper article" was 2. Fifty percent of aforementioned articles were published by 1-3 and 1-2 authors respectively.

| Publication type	Mean	Median	Mode	Minimum	Maximum	Percentile 25	Percentile 75	Number of publications
Academic article in a peer-reviewed journal	7	6	5	1	127	4	8	6655
Academic literary review in a peer-reviewed journal	5	4	3	1	65	2	6	402
Conference article or abstract	5	4	4	1	22	3	6	357
Academic book	3	2	2	1	9	2	4	35
Chapter in academic book	3	3	2	1	14	2	4	245
Doctoral dissertation	1	1	1	1	5	1	1	219
Report	5	4	2	1	22	2	7	40
Article in trade journal or book	2	2	1	1	12	1	3	190
Popular scientific article, newspaper article	2	1	1	1	13	1	2	84

Table 3. Publications of the pharmacy faculties and departments 2011-2016: number of authors per publication type.

The share of co-authored publications was high: 92.7% of all publications were co-authored. Among academic articles (publication types "Academic article in a peer-reviewed journal" or "Academic literary review in a peer-reviewed journal") the percentage was even higher, 97.4% of these articles were co-authored.

Similar shares of co-authored publications were found in Puuska's (2014) study. The mean number of authors in articles in peer-reviewed journals in the present study is quite similar to Piro's (2013) and Puuska's (2014) studies. The share of co-authored publications, and the mean number of authors is slightly higher in this study than in Dotson's (2011) study, focusing on authorship and characteristics of articles in pharmacy journals. The difference can be due to the fact that the present study focuses on a different timeframe, and the difference may reflect the general increase of the number of authors.

Distribution of articles to journals
Academic articles and literary reviews in peer-reviewed journals (n=7057) were published in 1660 journals. The distribution of articles to journals was skewed, only a few journals published many articles and a great number of journals published only a few articles. The distribution of publications to different journals is presented in Graph 1 and in Appendix Table 1.
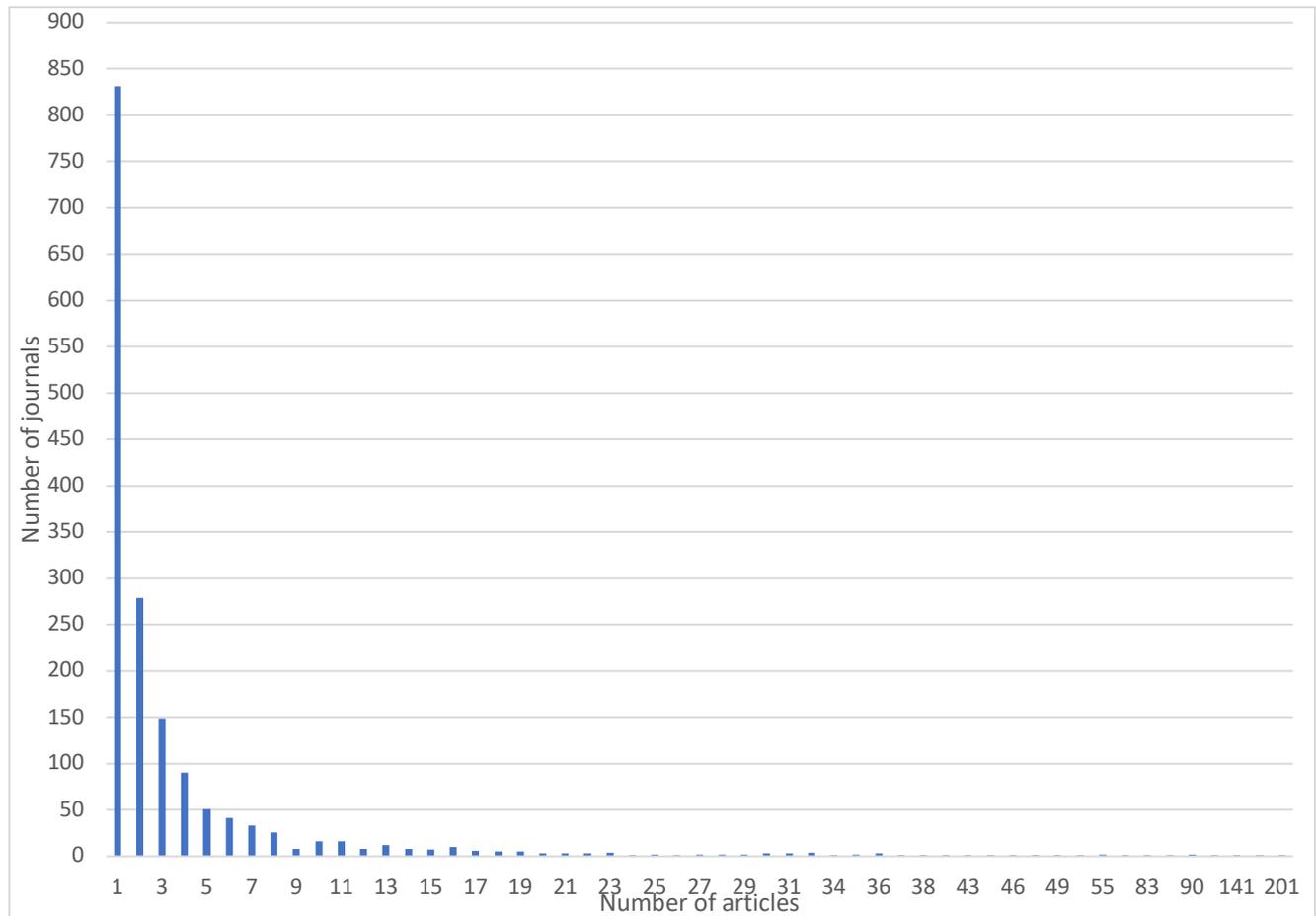
Graph 1. Academic articles and literary reviews of the pharmacy faculties and departments 2011-2016: distribution to journals. Number of articles n=7057, number of journals n=1660.

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When journals were ordered in descending order by the number of published articles, the Pareto principle, also known as the 80/20- rule, was supported by this dataset, since 80% of the articles were published by 33% of the journals. The negative binomial distribution of this kind is a typical bibliometric result (Bensman, 2000). Bradford's Law of Scattering (Bradford, 1971) and Garfield's Law of Concentration (Garfield, 1972) follow this distribution. These bibliometric laws describe the distribution of academic articles to journals. Similar highly skewed distributions were found in a study about the productivity of pharmacy deans (Thompson, 2019) and in a study mapping core hospital pharmacy journals (Barrett et al., 2016).

Journals and the Web of Science classifications
The majority of the journals, 88% (1470) were indexed in the Web of Science-database. These journals published altogether 80.1% (6592) of the publications in this dataset.

In Web of Science, journals are classified by their subject into different subject categories. A journal can belong to one or more categories. In this dataset, half of the journals belonged to only one category, and half belonged to two or more categories. For more detailed data about the number of subject categories of articles and journals, see Appendix (Table 2).

The journals were classified into 164 different subject categories. Categories with more than 100 articles are presented in Table 4. The largest category was "Pharmacology & Pharmacy" with 186 journals and 2080 articles. "Biochemistry & Molecular biology" was the next largest category with 156 journals and 763 articles. The third category was "Chemistry, Medicinal" with 47 journals and 708 articles. Most of the categories can be associated to more general categories of biosciences, chemistry, and medicine. These results emphasize the multidisciplinary nature of pharmacy.

Web of Science subject category	Number of articles	Percentage of articles	Number of journals	Percentage of journals
Pharmacology & Pharmacy	2080	18,7	186	7,4
Biochemistry & Molecular Biology	763	6,9	156	6,2
Chemistry, Medicinal	708	6,4	46	1,8
Chemistry, Multidisciplinary	570	5,1	57	2,3
Chemistry, Analytical	401	3,6	46	1,8
Neurosciences	388	3,5	99	3,9
Biochemical Research Methods	351	3,2	51	2,0
Multidisciplinary Sciences	308	2,8	16	0,6
Chemistry, Organic	290	2,6	30	1,2
Toxicology	248	2,2	53	2,1
Oncology	236	2,1	74	2,9
Medicine, Research & Experimental	193	1,7	50	2,0
Chemistry, Physical	171	1,5	37	1,5
Endocrinology & Metabolism	170	1,5	54	2,1
Cell Biology	160	1,4	66	2,6
Biophysics	159	1,4	37	1,5

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Plant Sciences	155	1,4	28	1,1
Public, Environmental & Occupational Health	152	1,4	42	1,7
Radiology, Nuclear Medicine & Medical Imaging	133	1,2	18	0,7
Materials Science, Multidisciplinary	122	1,1	31	1,2
Biotechnology & Applied Microbiology	121	1,1	58	2,3
Psychiatry	121	1,1	55	2,2
Microbiology	120	1,1	37	1,5
Clinical Neurology	112	1,0	48	1,9
Medicine, General & Internal	107	1,0	34	1,4
Nanoscience & Nanotechnology	102	0,9	33	1,3

Table 4. Academic articles and literary reviews of the pharmacy faculties and departments 2011-2016: Web of Science categories with more than 100 articles. The table shows the number and percentage of articles and journals by the Web of Science journal categories. A journal, and therefore an article, can belong to more than one category. Thus, percentages have been counted using number of journals (n=2523), number of articles (n=11106).

In addition to previously mentioned categories, articles were published to a smaller extent in journals categorized to technology and engineering oriented categories such as "Materials Science, Multidisciplinary" and "Computer Science, Interdisciplinary Applications" as well as behavioural sciences and social sciences oriented categories such as "Behavioral Sciences", "Psychology, Clinical" and "Education, Scientific Disciplines".

What are the core journals in pharmacy?
Half of the articles (49.5%) were published by 7% of the journals (see Appendix Table 1). These 120 journals published 12-201 articles. Of these 120 journals, 114 were found in Web of Science, and thus the Web of Science classification was available for those journals. Journals belonged to 42 different Web of Science-categories. Almost half of the journals (46) were classified into the "Pharmacology & Pharmacy"-category. Among the 120 journals were also six national pharmaceutical and medical journals. Only one of the national journals was indexed in Web of Science, namely "Tidsskrift for Den norske legeforening". For more detailed data about the 120 core journals, see Appendix Table 3.

Table 5 presents the 25 journals that published the largest number of the articles in descending order. The most used journal was "PLoS One," a multidisciplinary open access journal. Another multidisciplinary open access journal, "Scientific Reports," was also among these journals. "PLoS One" is followed by journals that publish articles about a wide variety of subjects within pharmaceutical sciences: "International Journal of Pharmaceutics," "European Journal of Pharmaceutical Sciences" and "Journal of Pharmaceutical Sciences".

Journal	Number of articles	Web of Science categories		
PloS one	201	Multidisciplinary Sciences		
International Journal of Pharmaceutics	153	Pharmacology & Pharmacy		

European Journal of Pharmaceutical Sciences	141	Pharmacology & Pharmacy		
Journal of Pharmaceutical Sciences	106	Chemistry, Medicinal	Chemistry, Multidisciplinary	Pharmacology & Pharmacy
European Journal of Pharmaceutics and Biopharmaceutics	90	Pharmacology & Pharmacy		
Journal of Medicinal Chemistry	90	Chemistry, Medicinal		
Molecular Pharmaceutics	88	Medicine, Research & experimental	Pharmacology & Pharmacy	
Dosis	83			
Pharmaceutical Research	65	Chemistry, Multidisciplinary	Pharmacology & Pharmacy	
European Journal of Nuclear Medicine and Molecular Imaging	55	Radiology, Nuclear Medicine & Medical Imaging		
Journal of Pharmacokinetics and Pharmacodynamics	55	Pharmacology & Pharmacy		
European Journal of Clinical Pharmacology	51	Pharmacology & Pharmacy		
Journal of Controlled Release	49	Chemistry, Multidisciplinary	Pharmacology & Pharmacy	
Journal of Biological Chemistry	48	Biochemistry & Molecular Biology		
Analytical Chemistry	46	Chemistry, Analytical		
Bioorganic and Medicinal Chemistry	45	Biochemistry & Molecular Biology	Chemistry, Medicinal	Chemistry, Organic
Scientific Reports	43	Multidisciplinary Sciences		
Basic & Clinical Pharmacology & Toxicology	41	Pharmacology & Pharmacy	Toxicology	
Analytical and Bioanalytical Chemistry	38	Biochemical Research Methods	Chemistry, Analytical	
Lægemiddelforskning	37			
European Journal of Medicinal Chemistry	36	Chemistry, Medicinal		
Journal of Ethnopharmacology	36	Plant Sciences	Chemistry, Medicinal	Integrative & Complementary Medicine

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Journal of Pharmaceutical and Biomedical Analysis	36	Chemistry, Analytical	Pharmacology & Pharmacy	
Drug Metabolism and Disposition	35	Pharmacology & Pharmacy		
Journal of labelled compounds & radiopharmaceuticals	35	Biochemical Research Methods	Chemistry, Medicinal	Chemistry, Analytical

Table 5. Academic articles and literary reviews of the pharmacy faculties and departments 2011-2016: the journals which published the largest number of articles, number of articles and their Web of Science categories. Number of articles n=7057, number of journals n=1660.

Discussion

The first objective of this study was to explore whether the selection of database and operationalization of the discipline affects the results of the bibliometric study of publishing patterns in pharmacy.

Using CRIS-databases as the source of data did not change the general picture of pharmacy publishing patterns. The study confirmed that publishing is focused on international scientific articles: academic articles and academic literary reviews in peer-reviewed journals written in English comprised 82,5% of the publications in this dataset. The academic articles in this dataset were published in scientific journals, of which a significant share was indexed in the Web of Science-database. This means that journal publishing in pharmacy can be studied reliably using international reference databases, as they include the majority of the most typical publication types used by pharmacy researchers.

Using data collected from CRIS-databases also provided new information. Even though there is a strong tendency towards international publishing in pharmacy, the results show that pharmacy researchers do also publish in national languages. In addition, there are several national journals amongst the core pharmacy journals. These results suggest that national publications have their own role in pharmacy publishing, even though the number of national journals and articles is small.

The second objective was to explore whether and how the multidisciplinary nature of pharmacy research manifests itself in publishing patterns. In earlier bibliometric studies of publishing patterns in pharmacy, the discipline has been operationalized using pharmacy journal sets. When a discipline is delineated using journal sets, the publications that pharmacy researchers have published in journals which are in other categories, are not included. Operationalizing pharmacy using pharmacy organizations provided new information, especially about the multidisciplinarity in pharmacy. Multidisciplinarity in pharmacy can be seen in pharmacy researchers' selection of journals as publishing outlets. Pharmacy researchers published their articles in journals representing a wide variety of Web of Science subject categories. Less than half of the core journals was categorized into the "Pharmacology & Pharmacy" category of Web of Science. These results show that journals representing different disciplines are important in pharmacy publishing. These results also show that studying only journals categorized as pharmacy journals does not give a full picture of pharmacy publishing patterns (AL-Ageel et al., 2020).

The result naturally also shows that subject categorizations are negotiable. In OECD's Field of Science and Technology-classification (OECD, 2015), pharmacy is classified under medicine and health sciences, which is of course a well-grounded decision. However, on the basis of the journals in which pharmacy researcher publish, there would also be good grounds to classify pharmacy into natural sciences.

When it comes to research evaluations, results that stress the multidisciplinary nature of pharmacy implicate the importance of using normalized citation indicators in research evaluation. There are differences in citation rates between disciplines, for example biochemistry and molecular biology publications receive on average 3 times more citations than analytical chemistry publications (Waltman et al., 2011). The results show that pharmacy scientists publish in journals from different subject fields. Normalized citation indicators take into account the publication type, publishing year and the subject category (Waltman et al., 2011) which makes it possible to compare publications from different subject categories with each other.

The limitations of this study are related to the known problems in combining data from different CRIS databases (Siversen, 2019). First, data collection principles may differ from one database to another, and they may change over time. Secondly, publication types aimed at other audiences than an academic audience are typically underreported (Puuska, 2014; Sīle, 2019). Comparing publication type frequencies between the universities gives an indication that this may be the case in the present data too. Publication type frequencies were consistent between universities in publications aimed for academic audiences, but the variation between the universities was greater in publication types aimed for other audiences. The combination of publication categories from different databases may also distort the distributions, as categories named similarly in different databases may actually contain publications of a different kind (Sīle, 2019). Creating a new categorization may have the same effect. Some simplifications of original categories were done in order to combine different categorizations. However, it is reasonable to assume that in the categories "Academic article in a peer-reviewed journal" and "Academic literary review in a peer-reviewed journal" the publications are quite similar because scientific articles and reviews are established publication types within medical and natural sciences. The other categories may have more variety because, for example reports, may take many forms. More detailed data about publication type frequencies across the six universities are provided in the Appendix Table 4. In addition, the data collected for the purposes of this study included publications from years 2011-2016. It is possible that there have been some changes in the publishing landscape (e.g., new journals have emerged) or in publishing patterns (e.g., in the number of authors) since 2016.

Recommendations for future research

There are interesting themes arising from the results for further studies. An important research question is the role of national publication channels in pharmacy. What is their role and what type of results are published in these journals? Another interesting aspect is the readership of national journals. Recent study of the readers of Finnish national journals showed that students are among the most active readers of these journals (Pölönen et al., 2021).

The study of multidisciplinarity in pharmacy could be deepened. In this study, the multidisciplinarity of pharmacy was explored though looking at the variations of journal subject categories. It would be important to study multidisciplinarity based on the individual articles' subjects or by using other bibliometric methods, such as citation analysis. Another interesting theme regarding multidisciplinarity concerns pharmacy subdisciplines. What kind of connections do various pharmacy subdisciplines have with other disciplines, for example, how do researchers from different pharmacy subdisciplines use or cite publications from other disciplines? What kinds of connections do subdisciplines have with each other?

Qualitative interviews with researchers could be used in addition to bibliometric methods (Hammarfelt, 2012). This would make it possible to study publishing practices from researchers' viewpoints and help in the interpretation of the results from bibliometric studies.

Conclusions

This study contributed to studies of publishing patterns in pharmacy by using data from institutional CRIS-databases and by using pharmacy organizations as the basis of operationalization of pharmacy.

Using CRIS-databases did not change the overall picture of pharmacy publishing patterns. In general, results are in line with earlier studies utilizing international databases. However, CRIS-databases do provide a more comprehensive picture of publishing patterns since they cover all publication types. Results showed that pharmacy researchers also publish in national languages and there were several national journals amongst the core journals. The multidisciplinary nature of pharmacy can be seen in the journal selection of pharmacy researchers. Pharmacy researchers published their articles in journals from a wide variety of Web of Science subject categories.

References

AL-Ageel, S., Mendes, A. M., Hasan, T., & Fernandez-Llimos, F. (2020). International collaboration in pharmacy practice research: A bibliometric analysis. *Research in Social and Administrative Pharmacy*, 16(11), 1513-1518. https://doi.org/10.1016/j.sapharm.2020.05.019

Barrett, A., Helwig, M., & Neves, K. (2016). Mapping the literature of hospital pharmacy. *Journal of the Medical Library Association*, 104(2), 118-124. https://doi.org/10.3163/1536-5050.104.2.005

Bensman, S. J. (2000). Probability distributions in library and information science: A historical and practitioner viewpoint. *Journal of the American Society for Information Science*, 51(9), 816-833. https://doi.org/10.1002/(SICI)1097-4571(2000)51:9<816::AID-ASI50>3.0.CO;2-6

Bradford, S.C. (1971). *Documentation* (2nd ed.). University Microfilms.

Dotson, B., McManus, K. P., Zhao, J. J., & Whittaker, P. (2011). Authorship and characteristics of articles in pharmacy journals: Changes over a 20-year interval. *Annals of Pharmacotherapy*, 45(3), 357-363. https://doi.org/10.1345/aph.1P610

Fry, J., & Talja, S. (2004). The cultural shaping of scholarly communication: Explaining e-journal use within and across academic fields. *Proceedings of the American Society for Information Science and Technology*, 41(1), 20-30. https://doi.org/10.1002/meet.1450410103

Garfield, E. (1972) Citation analysis as a tool in journal evaluation: Journals can be ranked by frequency and impact of citations for science policy studies. *Science,* 178(4060), 471-479. https://doi.org/10.1126/science.178.4060.471

Hammarfelt, B. (2012). Following the footnotes: A bibliometric analysis of citation patterns in literary studies. Doctoral dissertation, Acta Universitatis Upsaliensis. urn:nbn:se:hb:diva-280

Hammarfelt, B. (2018). What is a discipline? The conceptualization of research areas and their operationalization in bibliometric research. In: R. Costas, T. Franssen, A. Yegros-Yegros (Eds.), *Proceedings of the 23rd International Conference on Science and Technology Indicators* (pp. 197-203). Centre for Science and Technology Studies. urn:nbn:se:hb:diva-15098

Kyvik, S. (1991). *Productivity in academia: Scientific publishing at Norwegian universities*. Universitetsforlaget.

Mendes, A. M., Tonin, F. S., Buzzi, M. F., Pontarolo, R., & Fernandez-Llimos, F. (2019). Mapping pharmacy journals: A lexicographic analysis. *Research in Social and Administrative Pharmacy*, 15(12), 1464-1471. https://doi.org/10.1016/j.sapharm.2019.01.011

Minguet, F., Salgado, T. M., Santopadre, C., & Fernandez-Llimos, F. (2017). Redefining the pharmacology and pharmacy subject category in the Journal Citation Reports using Medical Subject Headings (MeSH). *International Journal of Clinical Pharmacy*, 39(5), 989-997. https://doi.org/10.1007/s11096-017-0527-2

Nasir, S., Ahmed, J., Asrar, M., & Gilani, A. (2015). A bibliometric analysis of pharmacy/pharmacology research in Pakistan. *International Journal of Pharmacology*, 11(7), 766-772. https://doi.org/10.3923/ijp.2015.766.772

OECD. (2015). *Frascati manual 2015: Guidelines for collecting and reporting data on research and experimental development*. OECD Publishing. https://doi.org/https://doi.org/10.1787/9789264239012-en

van Raan, A. (2019) Measuring Science: Basic principles and applications of advanced bibliometrics. In W. Glänzel, H. Moed, U. Schmoch & M. Thelwall (Eds.), *Springer handbook of science and technology indicators* (1st ed., pp. 237–280). Springer International Publishing. https://doi.org/10.1007/978-3-030-02511-3

Piro, F. N. (2013). A macro analysis of productivity differences across fields: Challenges in the measurement of scientific publishing. *Journal of the American Society for Information Science and Technology*, 64(2), 307-320. https://doi.org/10.1002/asi.22746

Puuska, H. (2014). *Scholarly publishing patterns in Finland: A comparison of disciplinary groups*. Tampere University Press. https://urn.fi/URN:ISBN:978-951-44-9480-2

Pölönen, J., Syrjämäki, S., Nygård, A-J, & Hammarfelt B. (2021). Who are the users of national open access journals? The case of the Finnish Journal.fi platform. *Learned Publishing*, 34(4), 585-592. https://doi.org/10.1002/leap.1405

Sīle, L. (2019). Entanglement of bibliographic database content and data collection practices: Rethinking data integration using findings from a European study. *Procedia Computer Science*, 146, 201-207. https://doi.org/10.1016/j.procs.2019.01.094

Sivertsen, G. (2019). Developing current research information systems (CRIS) as data sources for studies of research. In W. Glänzel, H. Moed, U. Schmoch & M. Thelwall (Eds.), *Springer handbook of science and technology indicators* (1st ed., pp. 667–683). Springer International Publishing. https://doi.org/10.1007/978-3-030-02511-3

Sweileh, W. M., Al-Jabi, S. W., Zyoud, S. H., & Sawalha, A. F. (2018). Bibliometric analysis of literature in pharmacy education: 2000-2016. *International Journal of Pharmacy Practice*, 26(6), 541-549. https://doi.org/10.1111/ijpp.12429

Sweileh, W. M., Zyoud, S. H., Sawalha, A. F., & Al-Jabi, S. W. (2014). A bibliometric study of community pharmacy-based research activity in Middle Eastern Arab countries: 2003-2012. *Tropical Journal of Pharmaceutical Research*, 13(9), 1549-1554. https://doi.org/10.4314/tjpr.v13i9.24

Thompson, D. F. (2019). Publication records and bibliometric indices of pharmacy school deans. *American Journal of Pharmaceutical Education*, 83(2), 189-196. https://doi.org/10.5688/ajpe6513

Thompson, D. F. (2018). Bibliometric analysis of pharmacology publications in the United States: A state-level evaluation. *Journal of Scientometric Research*, 7(3), 167-172. https://doi.org/10.5530/jscires.7.3.27

UiT The Arctic university of Norway. (2021, May 22). *Department of pharmacy*. https://en.uit.no/enhet/ifa

University of Copenhagen. (2021a, May 22). *Department of drug design and pharmacology*. https://drug.ku.dk/

University of Copenhagen. (2021b, May 22). *Department of pharmacy*. https://pharmacy.ku.dk/

University of Eastern Finland. (2021, May 22). *The School of pharmacy*.
https://www3.uef.fi/en/web/farmasia/home

University of Helsinki. (2021, May 22). *Faculty of pharmacy*. https://www.helsinki.fi/en/faculty-of-pharmacy

University of Oslo. (2021, May 22). *UiO, Department of pharmacy, The Faculty of mathematics and natural sciences*. https://www.mn.uio.no/farmasi

Uppsala University. (2021, May 22). *Disciplinary domain of medicine and pharmacy*.
https://www.medfarm.uu.se/

Waltman, L., van Eck, N. J., van Leeuwen, T. N., Visser, M. S., & van Raan, A. F. J. (2011). Towards a new Crown indicator: An empirical analysis. *Scientometrics*, 87(3), 467-481.
https://doi.org/10.1007/s11192-011-0354-5

Weathers, T., & Unni, E. (2018). Publication rates of social and administrative sciences pharmacy faculty in non-research intensive pharmacy schools. *American Journal of Pharmaceutical Education*, 82(3), 253-258. https://doi.org/10.5688/ajpe6229

Web of Science. (2021, May 22). *Web of science core collection help - Web of science categories.*
https://images.webofknowledge.com/WOKRS56B5/help/WOS/hp_subject_category_terms_tasca.html

Whitley R. (2000). *The intellectual and social organization of the sciences* (2nd ed.). Oxford University Press.

Zitt M., Lelu A., Cadot M.& Cabanac G. (2019). Bibliometric delineation of scientific fields. In W. Glänzel, H. Moed, U. Schmoch & M. Thelwall (Eds.), *Springer handbook of science and technology indicators* (1st ed., pp. 25–68). Springer International Publishing. https://doi.org/10.1007/978-3-030-02511-3

Appendix

Number of academic articles or academic literary reviews in a peer-reviewed journal	Number of Journals	Total number of articles (A*B)	% of articles (n=7057)	% of journals (n=1660)	Cumulative number of articles	Cumulative number of journals	Cumulative % of articles	Cumulative percentage of journals
201	1	201	2,8	0,06	201	1	2,8	0,06
153	1	153	2,2	0,06	354	2	5,0	0,12
141	1	141	2,0	0,06	495	3	7,0	0,18
106	1	106	1,5	0,06	601	4	8,5	0,24
90	2	180	2,6	0,12	781	6	11,0	0,36
88	1	88	1,2	0,06	869	7	12,3	0,42
83	1	83	1,2	0,06	952	8	13,4	0,48
65	1	65	0,9	0,06	1017	9	14,4	0,54
55	2	110	1,6	0,12	1127	11	15,9	0,66
51	1	51	0,7	0,06	1178	12	16,6	0,72
49	1	49	0,7	0,06	1227	13	17,3	0,78
48	1	48	0,7	0,06	1275	14	18,0	0,84
46	1	46	0,7	0,06	1321	15	18,7	0,90
45	1	45	0,6	0,06	1366	16	19,3	0,96
43	1	43	0,6	0,06	1409	17	19,9	1,02
41	1	41	0,6	0,06	1450	18	20,5	1,08
38	1	38	0,5	0,06	1488	19	21,0	1,14
37	1	37	0,5	0,06	1525	20	21,6	1,20
36	3	108	1,5	0,18	1633	23	23,1	1,39
35	2	70	1,0	0,12	1703	25	24,1	1,51
34	1	34	0,5	0,06	1737	26	24,6	1,57
32	4	128	1,8	0,24	1865	30	26,4	1,81
31	3	93	1,3	0,18	1958	33	27,7	1,99
30	3	90	1,3	0,18	2048	36	29,0	2,17
29	2	58	0,8	0,12	2106	38	29,8	2,29
28	2	56	0,8	0,12	2162	40	30,6	2,41
27	2	54	0,8	0,12	2216	42	31,4	2,53
26	1	26	0,4	0,06	2242	43	31,7	2,59
25	2	50	0,7	0,12	2292	45	32,4	2,71
24	1	24	0,3	0,06	2316	46	32,8	2,77

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23	4	92	1,3	0,24	2408	50	34,1	3,01
22	3	66	0,9	0,18	2474	53	35,0	3,19
21	3	63	0,9	0,18	2537	56	35,9	3,37
20	3	60	0,9	0,18	2597	59	36,8	3,55
19	5	95	1,3	0,30	2692	64	38,1	3,86
18	5	90	1,3	0,30	2782	69	39,4	4,16
17	6	102	1,4	0,36	2884	75	40,8	4,52
16	10	160	2,3	0,60	3044	85	43,1	5,12
15	7	105	1,5	0,42	3149	92	44,6	5,54
14	8	112	1,6	0,48	3261	100	46,2	6,02
13	12	156	2,2	0,72	3417	112	48,4	6,75
12	8	96	1,4	0,48	3513	120	49,7	7,23
11	16	176	2,5	0,96	3689	136	52,2	8,19
10	16	160	2,3	0,96	3849	152	54,5	9,16
9	8	72	1,0	0,48	3921	160	55,5	9,64
8	26	208	2,9	1,57	4129	186	58,5	11,20
7	33	231	3,3	1,99	4360	219	61,7	13,19
6	41	246	3,5	2,47	4606	260	65,2	15,66
5	51	255	3,6	3,07	4861	311	68,8	18,73
4	90	360	5,1	5,42	5221	401	73,9	24,16
3	149	447	6,3	8,98	5668	550	80,3	33,13
2	279	558	7,9	16,81	6226	829	88,2	49,94
1	831	831	11,8	50,06	7057	1660	100,0	100,00

Appendix Table 1. The academic articles and literary reviews of the pharmacy faculties and departments 2011-2016: distribution of articles to journals. Number of articles n=7057, number of journals n=1660.

Number of Web of Science Categories	Number of individual articles	Number of journals
1	3638	751
2	1747	464
3	912	192
4	251	51
5	30	8
6	14	4
Total	6592	1470

Appendix Table 2. The academic articles and literary reviews of the pharmacy faculties and departments 2011-2016: number of Web of Science categories.

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Journal	Number of articles	Web of Science categories			
PloS one	201	Multidisciplinary Sciences			
International Journal of Pharmaceutics	153	Pharmacology & Pharmacy			
European Journal of Pharmaceutical Sciences	141	Pharmacology & Pharmacy			
Journal of Pharmaceutical Sciences	106	Chemistry, Medicinal	Chemistry, Multidisciplinary	Pharmacology & Pharmacy	
European Journal of Pharmaceutics and Biopharmaceutics	90	Pharmacology & Pharmacy			
Journal of Medicinal Chemistry	90	Chemistry, Medicinal			
Molecular Pharmaceutics	88	Medicine, Research & experimental	Pharmacology & Pharmacy		
Dosis	83				
Pharmaceutical Research	65	Chemistry, Multidisciplinary	Pharmacology & Pharmacy		
European Journal of Nuclear Medicine and Molecular Imaging	55	Radiology, Nuclear Medicine & Medical Imaging			
Journal of Pharmacokinetics and Pharmacodynamics	55	Pharmacology & Pharmacy			
European Journal of Clinical Pharmacology	51	Pharmacology & Pharmacy			
Journal of Controlled Release	49	Chemistry, Multidisciplinary	Pharmacology & Pharmacy		
Journal of Biological Chemistry	48	Biochemistry & Molecular Biology			
Analytical Chemistry	46	Chemistry, Analytical			
Bioorganic and Medicinal Chemistry	45	Biochemistry & Molecular Biology	Chemistry, Medicinal	Chemistry, Organic	
Scientific Reports	43	Multidisciplinary Sciences			
Basic & Clinical Pharmacology & Toxicology	41	Pharmacology & Pharmacy	Toxicology		
Analytical and Bioanalytical Chemistry	38	Biochemical Research Methods	Chemistry, Analytical		
Lægemiddelforskning	37				
European Journal of Medicinal Chemistry	36	Chemistry, Medicinal			
Journal of Ethnopharmacology	36	Plant Sciences	Chemistry, Medicinal	Integrative & Complementary Medicine	Pharmacology & Pharmacy
Journal of Pharmaceutical and Biomedical Analysis	36	Chemistry, Analytical	Pharmacology & Pharmacy		

Drug Metabolism and Disposition	35	Pharmacology & Pharmacy			
Journal of labelled compounds & radiopharmaceuticals	35	Biochemical Research Methods	Chemistry, Medicinal	Chemistry, Analytical	
Langmuir	34	Chemistry, Multidisciplinary	Chemistry, Physical	Materials Science, Multidisciplinary	
Bioorganic & Medicinal Chemistry Letters	32	Chemistry, Medicinal	Chemistry, Organic		
Journal of Chemical Information and Modeling	32	Chemistry, Medicinal	Chemistry, Multidisciplinary	Computer Science, Information Systems	Computer Science, Interdisciplinary Applications
Neurochemical Research	32	Biochemistry & Molecular Biology	Neurosciences		
Planta Medica	32	Plant Sciences	Chemistry, Medicinal	Integrative & Complementary Medicine	Pharmacology & Pharmacy
AAPS Journal	31	Pharmacology & Pharmacy			
Antimicrobial Agents and Chemotherapy	31	Microbiology	Pharmacology & Pharmacy		
Journal of Chromatography A	31	Biochemical Research Methods	Chemistry, Analytical		
British Journal of Clinical Pharmacology	30	Pharmacology & Pharmacy			
ChemMedChem	30	Chemistry, Medicinal	Pharmacology & Pharmacy		
Research in Social and Administrative Pharmacy	30	Public, Environmental & Occupational Health	Pharmacology & Pharmacy		
International Journal of Clinical Pharmacy	29	Pharmacology & Pharmacy			
Journal of Natural Products	29	Plant Sciences	Chemistry, Medicinal	Pharmacology & Pharmacy	
Biomaterials	28	Engineering, Biomedical	Materials Science, Biomaterials		
CPT: pharmacometrics and systems pharmacology	28	Pharmacology & Pharmacy			
Journal of Drug Delivery Science and Technology	27	Pharmacology & Pharmacy			
Molecules	27	Biochemistry & Molecular Biology	Chemistry, Multidisciplinary		
RSC Advances	26	Chemistry, Multidisciplinary			
Journal of Organic Chemistry	25	Chemistry, Organic			
Pharmacoepidemiology and Drug Safety	25	Public, Environmental & Occupational Health	Pharmacology & Pharmacy		
Biomacromolecules	24	Biochemistry & Molecular Biology	Chemistry, Organic	Polymer Science	

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Journal of Nuclear Medicine	23	Radiology, Nuclear Medicine & Medical Imaging			
MedChemComm	23	Biochemistry & Molecular Biology	Chemistry, Medicinal		
Therapeutic Drug Monitoring	23	Medical Laboratory Technology	Pharmacology & Pharmacy	Toxicology	
Toxicology letters	23	Toxicology			
Analytica Chimica Acta	22	Chemistry, Analytical			
Current Pharmaceutical Design	22	Pharmacology & Pharmacy			
European Journal of Hospital Pharmacy	22	Pharmacology & Pharmacy			
Biochemical Pharmacology	21	Pharmacology & Pharmacy			
British Journal of Pharmacology	21	Pharmacology & Pharmacy			
Journal of Pharmacy and Pharmacology	21	Pharmacology & Pharmacy			
Drug Development and Industrial Pharmacy	20	Chemistry, Medicinal	Pharmacology & Pharmacy		
Neuropharmacology	20	Neurosciences	Pharmacology & Pharmacy		
Proceedings of the National Academy of Sciences of the United States of America	20	Multidisciplinary Sciences			
Clinical Pharmacology and Therapeutics	19	Pharmacology & Pharmacy			
Norsk Farmaceutisk Tidsskrift	19				
Nuclear Medicine and Biology	19	Radiology, Nuclear Medicine & Medical Imaging			
Tetrahedron Letters	19	Chemistry, Organic			
Xenobiotica	19	Pharmacology & Pharmacy	Toxicology		
ACS Medicinal Chemistry Letters	18	Chemistry, Medicinal			
European Journal of Organic Chemistry	18	Chemistry, Organic			
Journal of Pharmacology and Experimental Therapeutics	18	Pharmacology & Pharmacy			
Molecular Pharmacology	18	Pharmacology & Pharmacy			
Toxicology in Vitro	18	Toxicology			
ACS Chemical Neuroscience	17	Biochemistry & Molecular Biology	Chemistry, Medicinal	Neurosciences	
Alcoholism: Clinical and Experimental Research	17	Substance Abuse			

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Angewandte Chemie International Edition	17	Chemistry, Multidisciplinary			
Bioanalysis	17	Biochemical Research Methods	Chemistry, Analytical		
Nature Communications	17	Multidisciplinary Sciences			
Organic and biomolecular chemistry	17	Chemistry, Organic			
Amino Acids	16	Biochemistry & Molecular Biology			
BMC Cancer	16	Oncology			
Chemistry: A European Journal	16	Chemistry, Multidisciplinary			
Colloids and Surfaces B: Biointerfaces	16	Biophysics	Chemistry, Physical	Materials Science, Biomaterials	
Electrophoresis	16	Biochemical Research Methods	Chemistry, Analytical		
Journal of Alzheimer's Disease	16	Neurosciences			
Journal of Antimicrobial Chemotherapy	16	Infectious Diseases	Microbiology	Pharmacology & Pharmacy	
Neurochemistry International	16	Biochemistry & Molecular Biology	Neurosciences		
Rapid Communications in Mass Spectrometry	16	Biochemical Research Methods	Chemistry, Analytical	Spectroscopy	
Suomen lääkärilehti	16				
Biochimica et Biophysica Acta - Biomembranes	15	Biochemistry & Molecular Biology	Biophysics		
International Journal of Cancer	15	Oncology			
Journal of Neurochemistry	15	Biochemistry & Molecular Biology	Neurosciences		
Organic Letters	15	Chemistry, Organic			
Scandinavian Journal of Gastroenterology	15	Gastroenterology & Hepatology			
Transplantation	15	Immunology	Surgery	Transplantation	
Ugeskrift for Laeger	15				
Advanced Drug Delivery Reviews	14	Pharmacology & Pharmacy			
Carbohydrate Polymers	14	Chemistry, Applied	Chemistry, Organic	Polymer Science	
Duodecim	14				
European Journal of Pharmacology	14	Pharmacology & Pharmacy			
Journal of Clinical Endocrinology and Metabolism	14	Endocrinology & Metabolism			
Pharmaceutics	14	Pharmacology & Pharmacy			

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Tetrahedron	14	Chemistry, Organic			
Tidsskrift for Den norske legeforening	14	Medicine, General & Internal			
AAPS PharmSciTech	13	Pharmacology & Pharmacy			
Biochemical and Biophysical Research Communications - BBRC	13	Biochemistry & Molecular Biology	Biophysics		
Bioconjugate Chemistry	13	Biochemical Research Methods	Biochemistry & Molecular Biology	Chemistry, Multidisciplinary	Chemistry, Organic
BMJ Open	13	Medicine, General & Internal			
Current Topics in Medicinal Chemistry	13	Chemistry, Medicinal			
Drug Testing and Analysis	13	Biochemical Research Methods	Chemistry, Analytical	Pharmacology & Pharmacy	
Journal of Cerebral Blood Flow and Metabolism	13	Endocrinology & Metabolism	Hematology	Neurosciences	
Journal of clinical pharmacology	13	Pharmacology & Pharmacy			
Journal of Peptide Science	13	Biochemistry & Molecular Biology	Chemistry, Analytical		
Journal of Proteome Research	13	Biochemical Research Methods			
Neuroscience Letters	13	Neurosciences			
Pharmaceutical Development and Technology	13	Pharmacology & Pharmacy			
Cancer Chemotherapy and Pharmacology	12	Oncology	Pharmacology & Pharmacy		
ChemBioChem	12	Biochemistry & Molecular Biology	Chemistry, Medicinal		
Clinical Cancer Research	12	Oncology			
Ecological Modelling	12	Ecology			
Expert Opinion on Drug Delivery	12	Pharmacology & Pharmacy			
Health Policy	12	Health Care Sciences & Services	Health Policy & Services		
Journal of Agricultural and Food Chemistry	12	Agriculture, Multidisciplinary	Chemistry, Applied	Food Science & Technology	
Journal of Physical Chemistry B	12	Chemistry, Physical			
Number of articles	3513				

Appendix Table 3. The academic articles and literary reviews of the pharmacy faculties and departments 2011-2016: the journals which published altogether 49,7% of the articles and reviews, number of articles and their Web of Science categories.

Publication type	University of Eastern Finland	University of Helsinki	University of Oslo	University of Tromsø	Uppsala University	University of Copenhagen	All Universities
Academic article in a peer-reviewed journal	76,60%	75,20%	75,50%	76,10%	84,00%	84,90%	80,90%
Academic literary review in a peer-reviewed journal	7,40%	6,70%	5,90%	7,90%	5,20%	2,50%	4,90%
Conference article or abstract	0,40%	4,10%	6,10%	5,40%	3,10%	6,20%	4,30%
Academic book	0,30%	0,30%	1,00%	0,70%	0,20%	0,50%	0,40%
Academic book chapter	2,10%	4,60%	2,60%	2,90%	2,30%	3,20%	3,00%
Doctoral dissertation	2,80%	2,40%	1,00%	2,10%	5,10%	1,70%	2,70%
Report	0,20%	0,30%	1,00%	1,10%	0,00%	0,80%	0,50%
Article in trade journal or book	8,40%	5,50%	2,20%	1,10%	0,00%	0,00%	2,30%
Popular scientific article, newspaper article	1,90%	1,00%	4,60%	2,90%	0,00%	0,20%	1,00%

Appendix Table 4. Publication types frequencies of pharmacy faculties and departments 2011-2016 by universities