http://doi.org/10.62405/osi.2024.02.02
UDC 004.65:025.4

MEASURING AND EVALUATION SCIENTIFIC DISCIPLINES IMPACT BASED ON CRIS SYSTEM DATA

Danica Zendulková,
Slovak Centre of Scientific and Technical Information
Gabriela Gavurníková,
Slovak Centre of Scientific and Technical Information
Ján Turňa,
Slovak Centre of Scientific and Technical Information
Anna Krivjanská,
Slovak Centre of Scientific and Technical Information

Abstract. *Setting the shares of individual scientific disciplines in the activities and results of science and research in Slovakia is important from the point of view of allocating funds, determining priorities for science at the national level and forming science-related policies. The purpose of the article is primarily to underline that in order to create a comprehensive analysis, high-quality data about research and development at the national level and in the required structure is essential.*

The aim of the analysis is to point out the importance of life sciences within the portfolio of science and research in Slovakia. The analysis is based on the methods of bibliometrics and scientometrics. The identification of available data sources was the first step. Then the data usability analysis was carried out. The next step was the selection of suitable indicators based on the best practice worldwide. We analysed not only publishing activity, but also subjects of science and research and project activities. We worked with data from the Web of Science (WoS) database and the information system on science and research SK CRIS. The analysis of quantitative indicators confirmed the significant representation of life sciences in the science and research portfolio in Slovakia, in all monitored indicators.

Such studies as ours one can help identify research trends, can help policy makers and researchers make informed decisions, and can help assess researchers, institutions, as well as performance of countries in scientific production and impact.

Keywords: *Science Evaluation; Research projects; Research results; Life sciences; Data analysis; Slovak Current Research Information System; SK CRIS.*

1. INTRODUCTION

Science, research, and development belong to the basic tools to support the growth of the national economy and society as a whole. The question of assessing and measuring the quality of science is a complex problem and does not have a single correct solution.

Setting the shares of individual scientific disciplines in the activities and results of science and research in Slovakia is important from the point of view of allocating funds, determining priorities for science at the national level and forming science-related policies. Therefore, analyses focusing on the results of specific areas of science are requested in order to create an argumentative base for central state administration bodies that create national science-related policies and allocate funds.

The role of Slovak Centre of Scientific and Technical Information (SCSTI) in this area follows from the position of national information centre for science, technology, innovation and education of the Slovak Republic. SCSTI's mission is, among other tasks, to promote the development of science, technology and education in Slovakia by building and operation of information systems for R&D and by methodological and analytical activities supporting the management and evaluation of research, development and higher education. The SCSTI is a subsidiary organization (public body) of the Ministry of Education, Research, Development and Youth of the Slovak Republic.

The purpose of the article is primarily to underline that in order to create a comprehensive analysis, high-quality data about research and development at the national level and in the required structure is essential. Only on their basis is it possible to select a suitable set of indicators for providing the necessary information for policymakers. Last but not least, we want to emphasize the importance of life sciences in the R&D in Slovakia.

When creating the methodology, we were primarily based on internationally used science evaluation systems. The decision on which indicators to monitor was inspired by science assessment systems, but was based on an analysis of available data sources. We selected those internationally used science assessment indicators for which we had available quality data. It can therefore be said that the selected indicators form the intersection of these two requirements. We chose life sciences for analysis, however the methodology can be used regardless of the chosen scientific field.

Indicators refer to all basic elements entering the research process. The basis is project activities, which are devoted to subjects — persons and organisations. Analysis of project teams is another indicator that we have also developed in the direction of gender equality indicators. We also analysed research results, especially publications and their author teams.

Within the framework of identifying limitations in data analysis, the article also contains several recommendations on science and research data and their management.

2. MATERIALS AND METHODS

Methods from several disciplines have been used to perform data analyses in science and research. First of all, the bibliometrics. Documents (publications) are the subject of bibliometric research, respectively their representation in the form of bibliographic records. A bibliometric study is a quantitative technique used to assess scientific production and its impact on a particular field of knowledge. It is based on the analysis of scientific publications and their citations, providing a detailed view of the research state in a specific area based on the analysis of scientific publications.

However, publications are only one of the characteristic attributes of research activity. In contrast to bibliometrics, scientometrics focuses exclusively on scientific publications within the analysis of publications and uses the results of the analysis of publications and citations primarily for the evaluation of science. In addition to scientific publications, scientometrics also examines other quantitative characteristics of science, such as per-son-years, number of years of experience of scientists, financial inputs, etc. [1]. Scientometrics allows us to summarize large amount of bibliometric data in order to present the state of knowledge and emerging trends of a research topic or field over time.

Our work stems from the theoretical and practical knowledge and experience at domestic and global level as there exist numerous methodologies and procedures to determine the performance of science and research.

The first step was the identification of data sources, within which it is possible to identify entities from Slovakia and their science and research activities, including results.

In the second step, data usability analysis was carried out. Data sources must contain structured data on science and research at the national level, the data must be interconnected, and must be of adequate quality and consistency. The classification of data ac-cording to scientific fields is also necessary.

Based on the data usability analysis, suitable indicators were identified and the structure of the output reports was determined. Subsequently, it was necessary to formulate search criteria and identify relevant records in terms of the topic of the performed analysis.

The last step was the evaluation and interpretation of the results obtained from the analysis and the development of conclusions and recommendations.

2.1. Scope

The evaluation of science by bibliometric methods has been very well developed theoretically. Numerous bibliometric analyses have been carried out in individual countries, focused on publishing activity at various levels: from institutional to national to international comparisons. The study [2] compares individual science evaluation systems and their parameters. National science assessment systems are addressed by Ochsner [3].

Interesting are the analyses, focused on selected scientific disciplines or more narrowly specified areas of science, usually aimed at solving pressing global problems. From the category of life sciences, the concerned areas are e.g. bioeconomics [4], natural treatment methods [5], or green and sustainable health care [6].

More comprehensively designed scientometric indicators are mainly used by various systems and methodologies intended primarily for the evaluation of science at universities. We can mention U-Multirank [7], SCImago Institutions Rankings (SIR) [8] or Leiden ranking [9].

2.2. Indicators

In individual evaluation systems, the indicators usually differ depending on whether the system works only with bibliographic data (publication activity) or whether it regards a scientometric analysis. The authors of the study [2] classified different quantitative metrics according to their types (impact, production and composite indicators), their levels of application (micro, meso, and macro) and their use (internal and external). Additionally, similarity analysis revealed a high correlation between several indicators, such as the authors' h-index, author publications, article citations and journal citations. This study focused exclusively on indicators related to publishing activity.

Bibliographic analysis normally contains generally monitored indicators suitable to achieve a mutual comparison (of countries, institutions, etc.). For example:

1. Number of articles by country (institution).
2. Number of articles relative to the country population.
3. Number of articles by institution (peer reviewed).
4. Research quality: (ranked in the top quartile).
5. Subjects: All Science Journal Classification (ASJC).
6. Field-weighted citations.
7. Collaboration: (Percentage of international collaboration and academic-corporate collaboration).
8. Number of citations [10].

The European project U-Multirank evaluated the publishing activity of universities according to the following criteria:

1. total number of publications;
2. joint publications with industry;
3. joint international publications;
4. numbers of citations normalized by scientific field;
5. share of publications with the highest worldwide citations;
6. joint regional publications.

However, this project also took into account data related to research activities. One of the methodological starting points for the U-Multirank project was the Carnegie classification [11] which is one of several methods applied to the evaluation of institutions providing higher education in the United States. [7]. The U-Multirank project also considers indicators related to teaching, project activities, women's participation, and knowledge transfer [12].

Similarly, the Dutch Leiden Ranking, created within The Centre for Science and Technology Studies (CWTS) of Leiden University, offers a set of indicators that provide university-level statistics on scientific impact, collaboration, open access publishing, and gender diversity [9].

In Slovakia, the evaluation of science differs depending on the type of research institution. In 2022, the Periodic Evaluation of Research, Development, Artistic and Other Creative Activities [13], or Verification of Excellence in Research 2022, was performed for the first time. It was effectuated as a peer review evaluation of the publishing and other creative activities of Slovak public universities and public research institutions for the period 2014–2019, the results of which are published online [14].

The workplaces of Slovak public universities and public research institutions were the subject of the evaluation, respectively, creative outputs produced by them. The periodic evaluation was administratively covered by the Ministry of Education, Research, Development and Youth of the Slovak Republic. The Ministry also covers the Assessment of Competence to Perform Research and Development, which is mainly intended for private and state research organizations. Organizations interested in the relevant certificate need to submit an electronic application form containing data, which is then evaluated by a specially created commission [15].

Main financial indicators used for the science evaluation are the following:

- total amount of funds invested in research and development;
- amount of funds broken down by sector of research and development;
- amount of funds according to funding resources;
- amount of funds according to the structure of the type of expenditure;
- indirect financing instruments, which include the so-called income tax super-deduction aimed at supporting investment in research and development in the business sector.

When analysing personnel resources in research and development, the following indicator is mostly used:

- employment in research and development broken down by sectors, scientific areas, and regions.

Among the bibliographic indicators belong:

- total number of publications per year;
- number of open access publications;
- number of frequently cited publications (HCP);
- total number of citations/number of citations to OA publications/number of citations to HCP;
- number of projects solved in the monitored year [16].

When it regards the technology transfer, indicators of the effectiveness of technology transfer have been formulated. The set of these indicators stems from the data available within the SK CRIS - Information System on Research, Development and Innovation (Table 1). [17]

For the purposes of this analysis were used both bibliometric and scientometric indicators. When formulating them, mainly the quality and complexity of the available data were considered. For this reason, we omitted, for example, financial indicators mainly related to using funds from public resources.

2.3. Data Sources

It is necessary to identify what ranges of information applicable to the evaluation of science and research are available to us. Primarily for the evaluation is used the data on publication activity. Relevant data sources include:

Table 1

The indicators of the effectiveness of technology transfer

Area	Group	Description
Human Potential	Formal pre-requisities	Classification of academics from aspects of research field, expertise, specialisation, research degrees, degrees in education, membership in national, international scientific organisations, awards etc.
Cooperation	Projects	Domestic and foreign research projects in various scientific fields
	Collaboration	Involvement of R&D institutions/teams in national or international collaboration
R&D environment	Infrastructure and services	Investment in research facilities, equipment Specific services provided by R&D institutions

Scientific publications and citation databases. International bibliographic databases are standardly used. The Web of Science (WoS) and SCOPUS databases are used for evaluation purposes because, in addition to information on publication activities, they also allow for tracking of citations of published works. For this purpose in Slovakia has been built the Central Register of Evidence of Publication Activity of Universities [18].

The implementation of the principles of open science in scientific communication provides a separate range of sources of information that are applicable in the science evaluation. These include institutional repositories containing digital documents, the products of the research, scientific, development, and other creative activities of a single institution or a consortium of institutions. It does not concern only full texts of publication outputs. It concerns mainly scientific data. These sources also include digital storage, i.e. an information system ensuring the storage, protection, integrity, authenticity, and availability of digital documents and data in the long term, serving mainly for storage and internal ac-cess to the full texts of the publication outputs of the given institution. However, the number of repositories and digital repositories is still low, compared to other countries [19], and the data from them is currently of marginal importance.

The information system on research and development (R&D) — SK CRIS, respecting the EU standards for research information, has been built in Slovakia for a long time. It contains data suitable for scientometric analysis. The SK CRIS information system [20] integrates data on science and research in Slovakia within the register of R&D organizations, register of R&D projects, register of researchers, register of R&D results and by the map of research infrastructure. The system enables the administration of the process of assessment to perform R&D, as well as the supplementary statistical survey of the research and development potential of the Ministry of Education, Science, Research, and Sport of the Slovak Republic. The system generates reference data (data necessary for the certificate of ability to perform R&D) and provides them to relevant entities, mainly funding agencies. The data of the registers are mostly open, and they are publicly available without the need for authentication into the system.

Databases related to industrial property are available. The Industrial Property Office of the Slovak Republic (ÚPV SR) registers and publishes databases related to patents, utility models, designs, and trademarks.

The statistical data from research performing organisations is collected, processed and published by the Statistical Office of the Slovak Republic [21], and also by the Ministry of Education, Science, Research and Sport of the Slovak Republic [22].

In our research, we decided to use the data from the SK CRIS information system and the WoS bibliographic scientific database.

2.4. Definition of Life Sciences and the possibility of their classification

If we want to obtain comprehensive data on subjects, activities, and outputs of science and research related to life sciences, it is necessary to define this category. Considering the existence of various classifications and code books with firmly defined categories for the purpose of identifying objects of science and research, it may not be easy.

Standardly, the life sciences use to be connected to the biological sciences. However, it is not accurate, living nature is a subject of other fields of science, excepting biological sciences, as well. For example, GoLifeSciences [23] provides a list of scientific areas of living nature, in which medical sciences are also included. The Times Higher Education World University Rankings [24] includes agriculture and forestry among the life sciences. Some disciplines need to be divided, and only relevant subdisciplines should be selected from them, for example, organic chemistry as part of chemical sciences. Some fields could belong to the life sciences but also to technical sciences, for example biotechnology. It needs to be taken into account that the living nature cannot be completely separated from non-living nature, or from society. For this reason, it is not possible to define the life sciences completely precisely.

Research projects registered in the SK CRIS are objectively categorised according to the code of science and technology fields [25]. The numbering of science and technology fields is three-level, where within the first level, projects are assigned to basic groups of scientific fields according to the Frascati manual [26] (from 2023 was added a new category of arts and science of art). The second level characterizes individual scientific fields (e.g. Biological Sciences), and the third level defines specific scientific fields (e.g. Molecular Biology).

Within the aforementioned classification used for the objective categorization of projects, it was necessary to identify those fields that deal with living nature.

The most relevant subgroup of Natural sciences, which deals with living nature, is Biological Sciences. For a complete mapping of life sciences, we decided to also map selected fields of other categories of natural sciences, such as: IT (bioinformatics), physics (biophysics) and chemistry (biochemistry, bioorganic chemistry, macromolecular chemistry, organic chemistry). The analysis also regards selected fields of Technical sciences (medical engineering, environmental biotechnology and industrial biotechnology), all Medical sciences, and selected fields of Agricultural sciences, specifically biotechnology in agriculture and veterinary sciences. We did not include fields that cannot be unambiguously included among the life sciences, such as plant and animal production, as well as forestry from the agricultural sciences. We also did not analyse any scientific fields from the field of Social sciences and Humanities, including Arts.

3. RESULTS

3.1. Organisations and Researchers

Organisations that are interested in financial support from public resources must undergo the process of assessing of the competence

Table 2

Number of Organisations and Researchers in the SK CRIS database

Scientific area	Number of Organisations: certified	Number of Organisations: all	Number of Researchers
NATURAL SCIENCES – Biological sciences	28	59	712
IT – Bioinformatics	–	–	1
Physical sciences – Biophysics	2	6	29
Chemical sciences – Bioorganic chemistry	1	1	11
• Biochemistry	4	9	57
• Macromolecular chemistry	–	1	56
• Organic chemistry	8	9	42
Total (natural sciences excepting biological sciences	15	26	196
ENGINEERING AND TECHNOLOGY – Medical engineering	11	15	18
Environmental biotechnology	2	6	9
Industrial biotechnology	11	15	34
Total (Engineering and technology)	24	36	61
MEDICAL SCIENCES	79	188	2893
AGRICULTURAL SCIENCES – Veterinary sciences	1	3	348
Biotechnology in agriculture	6	14	39
Total (agricultural sciences)	7	17	387
TOTAL	153	326	4249

Source: *the SKCRIS database, 30th March.2024.*

to perform research and development. At the end of 2023, there were 792 organizations that held certificates of competence to perform R&D, which is less than a third of all research organizations registered on the SK CRIS portal.

The representation of organisations and researchers working in the field of living nature sciences demonstrates the Table 2.

The table shows that less than 19% of organisations with a certificate to perform R&D activities is from the life sciences. The share of life sciences organisations on the total number of all R&D organisations evidenced on the SK CRIS (with or without the certificate) is only 12.5%. Regarding researchers, the share is only 11.3%, but considering the large number of registered employees in scientific and technical services in the database, the lower share is not a surprise. Necessary to underline, that the data has been recorded for the entire period of building the SK CRIS database, which in some cases has been since 2000. The "age" of the data often has a negative effect on its timeliness and quality.

Therefore, in the next step we analysed the current data on project activities.

3.2. Monitoring of project activities

For the monitoring of project activities, we survey the indicator Number of projects solved in a given year. It concerns the projects either completely implemented in the monitored year, or in the case of multi-year projects, their implementation either started that year, or were handled throughout the year, or were completed in the concerned year.

For comparison, we present the data on the number of projects realized in 2020–2022. In 2020, Slovak research and development organizations realized totally 4148 projects, in 2021 up to 4498 projects and in 2022 up to 4226 projects (Figure 1)

3.3 Involvement of women in the projects teams

The share of women participating in research projects is more than 45 %. In our calculation, we considered that one researcher participated in the realization of two projects on average in both monitored years.

If we count every researcher who was involved in at least one project exactly once in the monitored period (regardless of the number of projects in which he was involved), there is still a slight dominance of men in project teams (about 52.5%).

If we survey the share of women according to the basic groups of scientific disciplines, the representation of women begins to differ depending on which group of scientific disciplines it is.

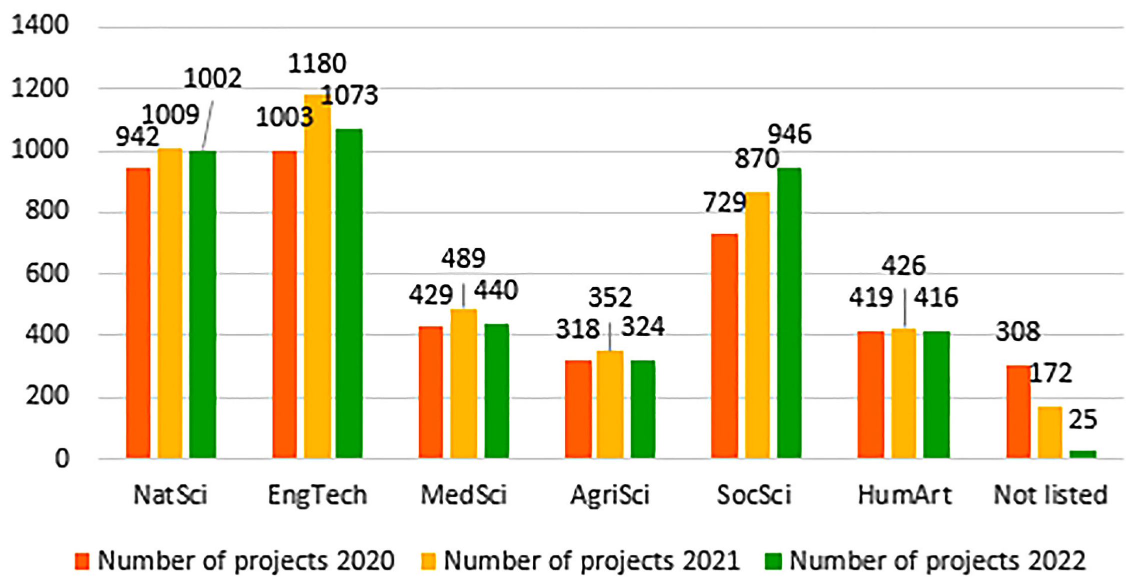

Fig. 1. Research projects by basic groups of R&D fields in 2020–2022

Table 3 contains data on the participation of women in 2021. In the overview of the representation of women in the given tables, we count a unique researcher as many times as in how many projects under various groups of scientific fields he was involved in. It is therefore possible for one researcher (working e.g. in the field of biotechnology) to participate in two projects in the monitored year, one in the field of natural sciences and the other in technical sciences.

Table 3 shows that the highest participation of women is in medical sciences projects and the lowest in technical sciences projects.

How does the share of women change if we process projects only for selected areas that fall under the life sciences? Due to the fact that the share of women in project teams changed only minimally from year to year, we selected the data from 2021. An overview of women's participation in projects realized in 2021 is in Table 4.

The share of women in biological sciences roughly corresponds to the share of women in medical sciences and in veterinary sciences and is the highest among the monitored categories (approx. 62–63%).

In biotechnologies in agriculture, the participation of women reaches 55.5%. Slightly more than half of women participated in the fields of natural sciences dealing with living nature but excepting biological sciences. Here predominated the chemistry, and biophysics and bioinformatics were also represented.

The lowest proportion of women (44%) can be observed in the field of biotechnology in technical sciences. This confirms the dominance of men in technical sciences, even though, compared to the share of women in Technical sciences as a whole (33%), the share of women in the field of biotechnology is still slightly higher.

As part of the analysis, 1025 life sciences oriented research projects implemented in 2021were identified. In total 4967 researchers were involved in these projects, out of which 3003 women and 1964 men.

Based on our results we can summarize that life sciences contribute by 22.8% to the number of realized projects in 2021 (4498 projects — total row in Table 5) and 36.7% to the number of researchers involved (without considering the multiple participation of one researcher in projects — Table 3). 60.5% of these researchers were women.

3.4 Publications

In 2021, Slovakia had 7 548 scientific publications registered in the bibliographic database of the WoS Core Collection/InCites [16]. Their breakdown by groups of science and technology fields demonstrates the Table 5.

The preponderance of publications in the field of natural sciences is significant, but this does not demonstrate the representation of life sciences. Some multidisciplinary publications

Table 3

Number of researchers in project teams by gender and science and technology field group, 2021

Group of Sciences	Number of Projects	Number of Researchers	Out of This Women	Percentage Share	Out of This Men	Percentage Share
NatSci	1009	3670	1744	47,52	1926	52,48
EngTech	1180	4122	1361	33,02	2761	66,98
MedSci	489	1820	1148	63,08	672	36,92
AgriSci	352	1357	691	50,92	666	49,08
SocSci	870	3430	1925	56,12	1505	43,88
HumArt	426	1567	805	51,37	762	48,63
Not listed	172					
Total	4498	15,966	7,674		8,292	

Source: *the SKCRIS database, 30th March.2024.*

Table 4

Project activity in life sciences and the involvement of women

Research area	Number of Projects	Number of Researchers	Out of This Women	Percentage Share	Out of This Men	Percentage Share
NATURAL SCIENCES – Biological sciences	305	1356	842	62,09%	514	37,91%
IT - Bioinformatics	2					
Physical sciences – Biophysics	15					
Chemical sciences – Bioorganic chemistry	4					
• Biochemistry	24					
• Macromolecular chemistry	15					
• Organic chemistry	20					
Total (natural sciences excepting biological sciences	80	447	232	51,90%	215	48,10%
ENGINEERING AND TECHNOLOGY – Medical engineering	14					
Environmental biotechnology	3					
Industrial biotechnology	16					
Total (Engineering and technology)	33	160	71	44,38%	89	55,63%
MEDICAL SCIENCES	489	1820	1148	63,08%	672	36,92%
AGRICULTURAL SCIENCES – Veterinary sciences	84	383	239	62,40%	144	37,60%
Biotechnology in agriculture	34	209	116	55,50%	93	44,50%
Total (agricultural sciences)	118	592	355	59,97%	237	40,03%
TOTAL	1025	4967	3003	60,46%	1964	39,54%

Source: *the SKCRIS database, 30th March.2024.*

were included simultaneously in categories that fall under two groups of disciplines. The line Total is therefore not the summary of the lines for individual groups of fields, and the percentage exceeds 100%.

The cited analysis was prepared in the autumn 2023. The number of registered publications has changed continuously over time; nowadays, this number no longer applies. A total of 7,674 publications were identified with the participation of Slovak authors as part of WoS in 2022[1]. The categorization of these publications is not entirely unequivocally comparable to the branches of science and technology used to

Table 5

Number of publications by R&D fields indexed in WoS, 2022[16]

Group of R&D fields	Number of publications	Percentage share
NATURAL SCIENCES	3752	49,7 %
ENGINEERING AND TECHNOLOGY	2298	30,44%
MEDICAL SCIENCES	1475	19,54 %
AGRICULTURAL SCIENCES	627	8,3 %
SOCIAL SCIENCES	1170	15,5 %
HUMANITIES	500	6,62 %
Total	7 548	

[1] WoS database, 12 March 2024

categorize projects. This avoids using the same criteria for projects as in the case of publications.

Working with WoS publications has its specifications; the most important fact is that the categorization of publications according to the fields is different from the classification according to the Frascati manual. At the same time, one publication can be assigned to several fields.

The corresponding country can be recognized according to the organisation identified in the article's author data.

In order to determine the share of publications that possibly fall into the life sciences, we used the same subject affiliation as for the projects (biological sciences, medical sciences, veterinary sciences, biotechnology, organic chemistry and biochemistry, etc.) and based on the number of publications (minimum 50) selected the categories listed in Table 6. The number of publications in these categories is 2009, which corresponds to less than a quarter of publications in a given year for all scientific disciplines.

The WoS does not distinguish the gender of the author. If we want to find out data about the authors' gender, we have no other option than to estimate the gender by the inflected surname and/or by the first name. This combination of Slovak authors makes it possible to determine the gender with almost 100% certainty.

Table 6

Life sciences publications in WoS, 2022

WoS Category	Number of publications
Biochemistry, Molecular Biology	335
Public Environmental Occupational Health	208
Medicine General Internal	138
Neurosciences	117
Oncology	113
Microbiology	104
Biology	102
Veterinary Sciences	97
Clinical Neurology	93
Cardiac Cardiovascular Systems	72
Endocrinology Metabolism	72
Biophysics	64
Genetic Heredity	50

When finding data on the gender of the authors, we used the function to display the most frequently publishing authors within the searched publications. Out of 200 authors of these publications displayed by the WoS user interface, are 60 women, which represents 30%. Their distribution in the first and second hundred authors is even.

It is distressful that the information about the authors with less than five publications cannot be obtained within the web interface search. We can only assume the approximate preservation of the ratio of the number of men and women even in the probably quite numerous category of authors with less than five publications in the observed year. We identified five women in the top twenty authors, which is 25 %.

4. DISCUSSION

During the analysis, we encountered several limitations. The challenge was to identify the fields of science that belong to the life sciences. The problem consisted in various classifica5ions, but mainly in the fact that individual scientific fields can produce articles devoted to life sciences topics, but also articles with predominantly other topics.

Another challenge was the selection of indicators analysed. Different evaluation methodologies and systems are not the only source of inspiration. It is necessary to start primarily from the available data and analytical tools and select a set of indicators for which we can obtain and evaluate the data.

It is important to mention that the selection and combination of analysed indicators can significantly influence or distort the result of the analysis. It should also be considered that although the WoS Core Collection database is multidisciplinary, articles from individual scientific disciplines might not be represented equally. Therefore, the percentage representation of individual scientific disciplines in this database may not exactly copy the representation of individual scientific disciplines within the framework of quality publication activity in general.

The variability of data in WoS over time is significant. This fact also occurs to a lesser extent within SK CRIS, where data is added with a rather long delay. Therefore, the indicator "Projects solved in year n" also shows changes in years n+1 and n+2. Therefore, the data for the analysis for the year 2022 can be considered final at the end of 2024. It is too late. Analysis needs to be available sooner. The compromise is the realization of analyses for the year 2022 after the end of 2023, when approximately 90–95% of all data is available.

Last but not least, the incompleteness and insufficient quality of data in information systems and databases can be limiting. Attention must certainly be paid to the unique identification of persons and organizations, the correct classification of individual objects into scientific areas, and to data management. Possible duplicates need to be eliminated.

5. CONCLUSIONS

The analysis confirmed the significant representation of life sciences in science and research in Slovakia, by all monitored indicators. The share of organizations from the field of life sciences in all registered organizations is less than 19%, and the share of researchers is only 11.3%. Considering the large number of registered staff of scientific and technical services in the database, this lower share is not surprising. Life sciences account for 22.8% of the number of solved projects in 2021 and 36.7% of the number of involved researchers.

These sciences also turned out very well in terms of gender equality, especially when considering composition of research teams in the research projects, represented by women by approximately 60%.

As for publications, less than a quarter of the total number of publications from all scientific disciplines are from the field of life sciences in a given year.

We can conclude that the analysis fulfilled its purpose helps make informed decisions and served for decision-making purposes by setting the parameters of science policy for the field of life sciences.

However, it is also necessary to address the effectiveness and appropriateness of the current approach to the science evaluation.

A question widely debated by stakeholders around the world is whether current research evaluation systems are effective enough in identifying high-quality research and supporting the advancement of science. Over recent years, concerns have risen about the limitations and potential biases of traditional evaluation metrics, which often fail to capture the full range of research impact and quality. The debates around the reform of research evaluation focus on various aspects of evaluation including the need for different and inclusive evaluation criteria, the role of peer review, and the role of open science. Considered are more comprehensive and qualitative assessment indicators, such as collaboration, data sharing, and community engagement [27].

Such studies as ours one can help identify research trends, can help policy makers and researchers make informed decisions, and can help assess researchers, institutions, as well as performance of countries in scientific production and impact.

Therefore, our further research will focus on the possibility of monitoring similar indicators within national information systems for science. Primarily, we will focus on cooperation where we have more data available already in the present.

REFERENCES

1. Ondrišová, M.: Bibliometria. Bratislava, STIMUL 2011. ISBN 978-80-8127-035-2. Available online: https://fphil.uniba.sk/fileadmin/fif/katedry_pracoviska/kkiv/Granty_a_projekty/Inwent/bibliometria_ondrisova.pdf

2. Ibrahim, N., Habacha Chaibi, A. and Ben Ghézala, H., Comparative study of science evaluation practices, VINE Journal of Information and Knowledge Management Systems, 2022, https://doi.org/10.1108/VJIKMS-12-2021-0293
3. Ochsner, Michael, Kulczycki, Emanuel, Gedutis, Aldis and Peruginelli, Ginevra. 2.3 National Research Evaluation Systems. Handbook Bibliometrics, edited by Rafael Ball, Berlin, Boston: De Gruyter Saur, 2021, pp. 99-106. https://doi.org/10.1515/9783110646610-011
4. Duquenne, M.; Prost, H.; Schöpfel, J.; Dumeignil, F. Open Bioeconomy — A Bibliometric Study on the Accessibility of Articles in the Field of bioeconomy. Publications 2020, 8, 55. https://doi.org/10.3390/publications8040055
5. Rodríguez-Redondo, Y.; Denche-Zamorano, A.; Muñoz-Bermejo, L.; Rojo-Ramos, J.; Adsuar, J.C.; Castillo-Paredes, A.; Vega-Muñoz, A.; Barrios-Fernandez, S. Bibliometric Analysis of Nature-Based Therapy Research. Healthcare 2023, 11, 1249. https://doi.org/10.3390/healthcare11091249
6. Berniak-Woźny, J.; Rataj, M. Towards Green and Sustainable Healthcare: A Literature Review and Research Agenda for Green Leadership in the Healthcare Sector. Int. J. Environ. Res. Public Health 2023, 20, 908. https://doi.org/10.3390/ijerph20020908
7. Shearman, A.: Prístupy k hodnoteniu vedeckovýskumnej činnosti na medzinárodnej a národnej úrovni. ITLib 2012, 1. Available online: https://itlib.cvtisr.sk/wp-content/uploads/docs/74_PRISTUPY%20K%20HODNOTENIU-Shearman.pdf
8. SCImago Institutions Rankings. Ranking Methodology. Available online: https://www.scimagoir.com/methodology.php
9. CWTS Leiden Ranking. Indicators. Available online: https://www.leidenranking.com/information/indicators
10. Dardas, L.A.; Malkawi, A.M.A.; Sweis, S.; Sweis, N.; Al-Khayat, A.; Sawair, F.A. Mapping Two Decades of Research Productivity in the Middle Eastern and Arab Countries: A Comprehensive Bibliometric Analysis. Publications 2023, 11, 48. https://doi.org/10.3390/publications11040048
11. Carnegie Classification of Institutions of Higher Education. Available online: https://carnegieclassifications.acenet.edu/
12. U-Multirank. Catalogue of Indicators. Available online: https://www.umultirank.org/about/methodology/indicators/
13. Ministerstvo školstva, vedy, výskumu a športu SR. Periodické hodnotenie výskumnej, vývojovej, umeleckej a ďalšej tvorivej činnosti. Available online: https://www.minedu.sk/33942-sk/periodicke-hodnotenie-vyskumnej-vyvojovej-umeleckej-a-dalsej-tvorivej-cinnosti/
14. Verification of Excellence in Research. Periodické hodnotenie výskumnej, vývojovej, umeleckej a ďalšej tvorivej činnosti. Available online: https://ver.cvtisr.sk/vysledky/
15. Centrálny informačný portál pre výskum, vývoj a inovácie. O certifikácii. Available online: https://www.vedatechnika.sk/sk/hodnotenie-sposobilosti-vykonavanie-vav/o-certifikacii/
16. Správa o stave výskumu a vývoja v Slovenskej republike a jeho porovnanie so zahraničím za rok 2022. (2022). Available online: https://rokovania.gov.sk/RVL/Material/29175/1
17. Shearman, A.: SK CRIS as an Information Resource for Technology Transfer. In: Informačné systémy o vede. Integrácia pre otvorený prístup k vedeckým výstupom [Research Information Systems: Integration for Open Access to Scientific Outputs.] Zborník z medzinárodnej konferencie. [Proceeding from International Conference] CVTI SR, Bratislava 2. apríla 2014, pp. 117–129 https://dspacecris.eurocris.org/handle/11366/239
18. Centrálny register evidencie publikačnej činnosti. Available online: www.crepc.sk
19. Národná stratégia pre otvorenú vedu na roky 2021-2028. (2021). Available online: https://www.openaire.eu/images/easyblog_articles/1406/Narodna-strategia-pre-otvorenu-vedu-2021-2028-.pdf
20. Informačný systém o vede a výskume SK CRIS. Available online: www.skcris.sk
21. ŠÚSR. Viacstranné štatistiky, Veda, technika a inovácie. Available online: www.statistics.sk
22. Centrálny informačný portál pre výskum, vývoj a inovácie. Štatistika. Available online: https://www.vedatechnika.sk/SK/VedaATechnikaVSR/Stranky/StatistickeUkazovatele.aspx
23. Go Life Sciences. Branches of Life Sciences. Available online: https://golifescience.com/life-sciences-

branches/
24. Times Higher Education World University Rankings. Available online: https://www.timeshighereducation.com/world-university-rankings-2024-subject-life-sciences-methodology
25. Číselník odborov vedy a techniky. Available online: https://www.vedatechnika.sk/SK/VedaATechnikaVSR/odboryVaT/Stranky/default.aspx
26. Frascati manuál. OECD 2002. Available online: https://www.vedatechnika.sk/SK/VedaATechnikaVSR/SDokumenty/Frascati%20manual/frascati%20manual%2001.pdf
27. The Future of Research Evaluation: A Synthesis of Current Debates and Developments - International Science Council. Available online: https://council.science/publications/the-future-of-research-evaluation-a-synthesis-of-current-debates-and-developments/

INFORMATION ABOUT THE AUTHORS

Danica Zendulková — Slovak Centre of Scientific and Technical Information, Lamačská cesta 8A, 840 05 Bratislava, Slovakia; e-mail: danica.zendulkova@cvtisr.sk; ORCID: 0000-0003-2487-0177

Gabriela Gavurníková — Slovak Centre of Scientific and Technical Information, Lamačská cesta 8A, 840 05 Bratislava, Slovakia; e-mail: gabriela.gavurnikova@cvtisr.sk; ORCID: 0000-0001-7096-6378

Ján Turňa — Slovak Centre of Scientific and Technical Information, Lamačská cesta 8/a, 84005 Bratislava, Slovakia, Faculty of Natural Sciences Comenius University Bratislava, Ilkovičova 6,842 15 Bratislava, Slovakia; e-mail: jan.turna@cvtisr.sk; ORCID: 0000-0001-5813-566X

Anna Krivjanská, — Slovak Centre of Scientific and Technical Information, Lamačská cesta 8A, 840 05 Bratislava, Slovakia; e-mail: anna.krivjanska@cvtisr.sk; ORCID 0000-0001-7765-0157