# eNauka – CRIS in Serbia

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**ABSTRACT:** The paper presents the basic entities and functionalities of eNauka - a publicly visible information system and portal created to provide an overview of scientific research activities in Serbia. The legal basis for the existence of such a system is described in detail, as well as all the sources from which data are collected/harvested in eNauka. For each of the sources, the shortcomings that have become apparent due to a large traffic, especially enhanced visibility, are also listed. Additionally, the paper describes the process of introducing eNauka into full production (enabling all functionalities for all end-users' roles), as well as experiences during training and end-user support implementation. Finally, the paper discusses future plans for improvement and conditions for its sustainability.

**KEYWORDS:** CRIS, eNauka, PIDs

## 1 Introduction

The basic aim of the digitization process of the scientific research sector is to gathering information of researchers, scientific research organizations, and their results. At the core of this process is the creation of an information technology basis for modernizing management and data-driven decision making, with the ultimate goal of ensuring a high quality and efficient scientific research system (e.g., rationalization of funding, reduction of administrative burden on all participants, etc.).

Systems aimed at achieving this goal are called CRIS (Wikipedia 2023), and teams dealing with the implementation of CRIS systems in Europe are united in the organization euroCRIS[1]. Commercial publishers/vendors have

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1. euroCRIS - The International Organization for Research Information

also recognized that decision-makers need such systems and have offered (financially burdensome) solutions, such asClarivate[2] and Elsevier-PURE[3].

In Serbia, there have been several attempts in the last twenty years to establish a national CRIS, but none have succeeded in satisfying all needs, especially in terms of the completeness and quality of data, orend-user support. Some of the systems mentioned are: IRIS, cris-NS (Ivanović et al. 2017), KNR-Vojvodina[4], Dositej[5], E-CRIS.SR[6] (Albahari 2017), RIS[7], BeOpen (Smederevac et al. 2020). All aforementioned systems have been supported in some way by the ministries responsible for science (financially or organizationally), indicating clearly that CRIS is an essential tool for decision-making. The Strategy of Scientific and Technological Development of the Republic of Serbia for the period from 2021 to 2025, "The Power of Knowledge," also envisaged that "a necessary condition for the dynamic development of the scientific research and innovation system, especially concerns the process of digitization and establishment of the information basis in the form of a unified national information system of scientific research activities" (PC 2021b).

For these reasons, at the end of 2021, the Office for Information Technology and Electronic Administration issued a public call for the construction of a Registry of Researchers in Serbia, based on which subject of this paper, information portal eNauka(NITRA 2023) was developed.

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## 2 Legal Basis

A mandatory condition for eNauka, based on databases maintained as Registers (researchers and research performing organizations- RPOs), is to

2. Converis – The essential tool for research information management, accessed 24. 10. 2023.

3. Pure – Leverage the world's leading Research Information Management System, accessed 24. 10. 2023

4. Research Register of Vojvodina (KNR), accessed 25. 10. 2023

5. Information Szstem DOSITEJ, accessed 25. 10. 2023

6. E-CRIS.SR, accessed 25. 10. 2023

7. Register of researchers in Serbia - RIS, accessed 25. 10. 2023.

8. eNauka, accessed 25. 10. 2023.

be fully compliant with the following aspects of theexisting legal framework in Serbia:

Law on Science and Research (PC 2019a):

− Article 6, paragraph 1 prescribes that in order to increase the quality and visibility of scientific work, research should be conducted in accordance with the principles of open science, with optimal use of research infrastructure. This includes e-infrastructures as well as databases and other systems necessary to achieve excellence in science and research;
− Article 21 prescribes the procedure for accreditation for conducting scientific research activities, i.e., obtaining the status of RPO;
− Articles 45, 47, and 50 prescribe that all types of institutes, i.e., scientific institutes, research and development institutes, and institutes of national importance for the Republic of Serbia, have scientific-information documentation and a library-information center in accordance with the law governing library-information activities;
− Article 68, paragraph 1 prescribes that the Ministry maintains a record of FROs that meet the conditions for conducting scientific research activities of general interest (FRO Register) and a record of researchers (Researcher Register); paragraph 2 prescribes that the purpose of maintaining these registers is planning and monitoring funding and the work of RPOs and researchers, monitoring the quality of research and research results, monitoring the advancement of researchers, improving the quality, efficiency, and effectiveness of the science and research system for better utilization of research results;
− Article 72 prescribes that data from the RPO Register and the Researcher Register are open data and publicly available on the Ministry's website in a processable format for use and further publication.

Law on Higher Education (Official Gazette of the Republic of Serbia, No. 88/2017) (PC 2023):

− Article 43 determines the types of higher education institutions and states that within the activities of higher education, a higher education institution, among other things, conducts scientific research and artistic activities;
− Article 72 prescribes that the teaching staff of a higher education institution consists of individuals engaged in educational, scientific, artistic, research, and innovation activities.

Law on Library and Information Activities (PC 2021a) :

– Article 14 prescribes that an educational and scientific institution is obliged to organize a school, higher education, university library, or library of a scientific research institute and institution and to provide all necessary conditions for its operation;

– Article 51 states that higher education and university libraries and libraries of scientific research institutes and institutions are organized to support and improve the educational, research, and scientific work of students, teachers, professors, and researchers.

Law on Electronic Administration (PC 2018):

– Article 9 regulates the exchange of data and documents in electronic form from registers maintained by the authority within its jurisdiction, through the Hub of the authority;

– Articles 10 - 11 prescribe the manner of establishing and maintaining registers and records in electronic form and the manner of using data from them;

– Article 13 prescribes the establishment and maintenance of the Meta-Register containing basic data on registers and records in electronic form, the basis for their establishment, the type of data collected with an indication of the origin of the data.

Personal Data Protection Law (PC, 2018a):

– Article 4 prescribes that the data controller is a natural or legal person or authority that independently or jointly with others determines the purpose and manner of processing, while the data processor is a natural or legal person or authority that processes personal data on behalf of the controller;

– Article 42 prescribes organizational and technical measures to protect data from misuse, destruction, loss, unauthorized changes, or access. The data controller and processor are obliged to take technical, personnel, and organizational measures to protect data, in accordance with established standards and procedures, necessary to protect the data from loss, destruction, unauthorized access, change, disclosure, and any other misuse, as well as to determine the obligation of employees involved in processing to maintain the confidentiality of data.

Regulation on Internal Organization and Job Classification (PC 2019b):

– Article 39, paragraph 4 envisages the establishment of a unified national system as a digitized unified system in the field of scientific research and innovation activities in the Republic of Serbia, including electronic databases maintained as registers.

## 3   System Description

eNauka is a publicly accessible portal for monitoring the scientific performance of researchers and institutions in the Republic of Serbia, which is aligned with international standards and practices to establish interoperability for data transfer. Behind eNauka is a flexible data model that enables the collection and management of research data and information typical for CRIS systems, defining entities and attributes through their reciprocal relationships. The system allows for the management of research profiles (e.g., name variants, ORCID, identifiers from other systems in Serbia, Scopus ID, etc.), the use of standard and various persistent identifiers (e.g., DOI, COBISS-Id, ScopusId), linking researchers to institutions, and so on. Such data models are called CERIF (Common European Research Information Format (euroCRIS 2023), and the data model applied in eNauka is developed according to this standard.

eNauka is comprised of two closely interconnected parts (Figure 1):

– An administrative part that ensures the registration of accredited RPOs in the RPO Register and the registration of researchers in the Researcher Register, and
– A publicly visible registry of results, which includes basic data about researchers and RPOs.

The administrative part encompasses the input and maintenance of general business and legal data about each RPO (Research Performing Organisation). The responsibility for the accuracy of administrative data about RPOs, or administrative-personal data of researchers, is entrusted to designated individuals within the institutions (RPOadministrator). This part of the system is linked to existing registries in the Republic of Serbia, such as the Unified Information System of Education (JISP), the Business Registers Agency (APR), and the Central Register of Social Insurance (CROSO).

If an institute, higher education institution, or institution of national significance meets all the conditions stipulated by the Law, the Accreditation Board makes a decision on the accreditation of that institution. The Ministry issues a decision on satisfying the conditions for conducting scientific research
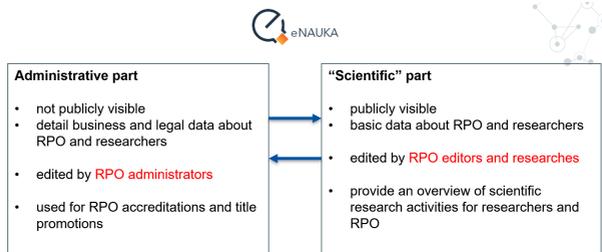
**Figure 1.** Facts and relationships between administrative and publicly visible registry of results

activities of general interest. Based on this decision, the Ministry registers the institution in the Register of Scientific Research Organizations.

RPOadministrators are responsible for entering, verifying, and updating basic personal data of researchers. They are responsible for all employed researchers, as well as for those researchers who are currently not employed but have obtained their research title within that RPO. The Register of Researchers includes individuals who have permanent residence or residence in the Republic of Serbia and have obtained the title of researcher in accordance with the Law on Science and Research, as well as individuals who have obtained titles in accordance with the law governing higher education.

Researchers and RPOs receive profiles on the publicly visible eNauka portal automatically (the next day) upon registration in the Register of Researchers or the Register of RPOs. Most titles and accreditations have expiration dates. Upon the expiration of the title/accreditation period, the "Active" status transitions to "Passive."

Data about results on the public eNauka portal are maintained by researchers and RPO editors. All data on eNauka are publicly available, which undoubtedly contributes to their accuracy and usability.

## 4 Data in eNauka - PIDs

In order to increase the interoperability of the system and utilize positive flows in the exchange of scientific information, data about RPOs, researchers, and results have been enriched with persistent identifiers, or PIDs. This enables connections with existing information systems in the country (such as E-CRIS.SR, KNR), as well as verification of the accuracy of result data

(such as DOI, PubMed, etc.). A list of all PIDs, along with explanations, is available in Table 1.

## 5    Data in eNauka - Results

The system initially loaded all results (publications) that existed in the previous RIS (Research Information System). The conversion was performed in May 2022, regardless of the fact that the data were not deduplicated at that time (a significant number of papers appeared multiple times), and the majority were unverified. Up to that point, the RIS was only partially publicly visible at the address http://istrazivaci.mpn.gov.rs/ (containing only published articles from journals up to 2017), which is likely the reason for the insufficient data quality. Retrieving data from the RIS was necessary because another request to researchers to enter data for all their outputs would have immediately led to an unfavorable status for eNauka in the scientific community. Although automatic deduplication was performed, we acknowledge that some unduplicated and low-quality data may still remain.

New data, as well as data for researchers who were not part of the RIS, are retrieved from other sources. The process is schematically shown in Figure 2.

Immediately following the data conversion from the RIS, data from all repositories in the RPOs were collected, provided they met the necessary condition of having an OAI/PMH server. This protocol for exchange was chosen as it is most commonly used for exchanging scientific information. In June 2022, 45 RPOsmaintain a repository/information system that met this condition. By October 2023, this number had increased to 110. About half of the institutions in this increase were not newly established repositories but had already had a repository or information system where OAI/PMH was implemented. Since data entry, verification, and supplementation in repositories are mostly done by librarians, the data collected in this manner are not additionally verified for accuracy in eNauka. It has also been observed that not all the advantages of PIDs have been applied in many systems, and it is expected that this practice will lead to improvement. Furthermore, a serious lack of IT support for maintaining infrastructure at institutions has been noted. Harvesting from these 110 sources is done regularly on a weekly basis.

The NaRDuS (National Repository of Doctoral Dissertations,[9] is also regularly harvested as a consolidated source of all doctoral dissertations de-
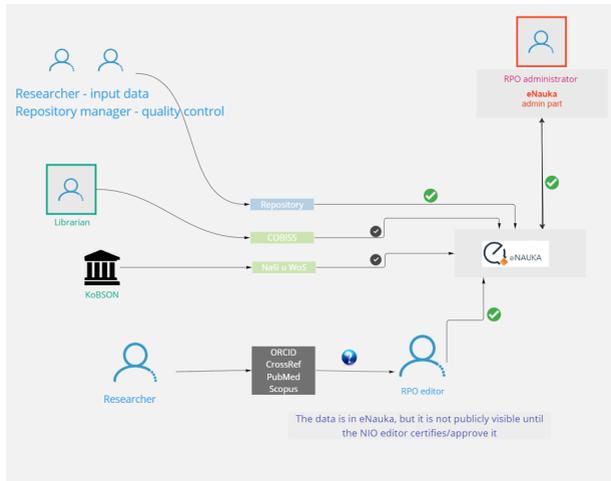
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9. NaRDuS, accessed 27. 10. 2023

**Figure 2.** Work-flow of harvest and modification of data about publications/results

fended in Serbia. These obligations, prescribed by the Law on Higher Education, are adhered to by all universities, although with some delays in deposition. Namely, the mentioned law has prescribed a deadline of 3 months after defense, which is not always respected, especially by universities with a larger number of defended dissertations.

In May 2023, following twelve months of negotiations, data from COBISS began to be regularly harvested (weekly). This source is valuable because COBISS covers the entire publishing production of the Republic of Serbia according to the Law on Mandatory Copy. Unfortunately, the analytical processing of articles from scientific journals and conference proceedings is neither timely nor comprehensive. Data from COBISS-NET member libraries indicated that there are librarians with cataloging licenses in the COBISS system in 93 RPOs (COBISS.SR 2023).

Given that the entire publishing activity in Serbia is cataloged in COBISS, it was necessary to extract only records relevant to scientific production. Therefore, a request was made to create such a set according to the following rules:

– in field 001 - completed subfield t (document typology)

– in field 7XX - filled in subfield 7, i.e. in the corresponding normative record in field 200 filled in subfield r (author/researcher's code).

With representatives from the University Library "Svetozar Marković" data exchange about the unique researcher identifier (eCRIS-Id, i.e., researcher code in the e-CRIS.SR system) was initiated, ensuring that all records harvested from COBISS and meeting the specified criteria are automatically linked to researcher profiles. Given that only licensedlibrarians input data into COBISS, these records also do not require verification. The implementation of this solution required cooperation with IZUM (the provider of the COBISS system) and was executed very efficiently, considering that the COBISS system already supports the OAI/PMH protocol for exchange. Through detailed data analysis, problems were identified with some data obtained from COBISS, the most common being:

– lack of document typologydata, which is now being supplemented,
– a large number of duplicates at the COBISS level,
– lack of and insufficiently precise PIDs (primarily DOI).

The broad visibility of eNauka will undoubtedly contribute to improving the quality of data in the COBISS.SR system and expedite coordinated actions at the COBISS.net level for better data quality.

In September 2023, data transfer from the Research Register of Vojvodina (KNR) was enabled, as this system has established the good practice of researchers in Vojvodina entering data about their results into KNR since 2012. Data from this system is not harvested; instead, the transfer is initiated by the researcher whose profile is associated with their APVNTid (a unique researcher identifier in KNR). The transfer component was developed in collaboration with the Computer Center of the Faculty of Technical Sciences at the University of Novi Sad.

In October 2023, the harvesting of data from Naši u WoS[10] (Timotijević, Kosanović, and Vasiljević 2013) service by the National Library of Serbia, Belgrade is expected to begin. This service is maintained by the Center for Scientific Information of the National Library of Serbia within KoBSON (Kosanovic 2004). It is envisaged that data from this source will not undergo verification by RPO-editors, as this service is maintained by librarians. The launch of eNauka has been postponed several times due to lengthy

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10. Податак је преузет са званичне веб стране Naši u WOS, accessed 24. 10. 2023.

negotiations and defining contractual obligations. However, after realizing the continuous delays, the decision was made to launch eNauka regardless of omitting records from this service. There are no consequences for researchers, but the time of RPO-editors spent verifying records that definitely exist in this source and were downloaded from other systems has been irretrievably wasted. At the time of writing this paper, a positive administrative step has been achieved, so it is expected that data from this system will soon be available in eNauka.

The collection of additional result data is initiated by the researcher, and the correctness of the metadata is verified by RPO-editors. This way, the responsibility for the completeness of the data lies with the researchers, while the quality of the metadata lies with the RPO-editors.

Researchers registered on eNaukacould log in exclusively using their OR-CIDiDs, using the same credentials for authentication as for editing their ORCID profiles. This was made possible due to NITRA[11] becoming a regular member of the ORCID organization. The ORCID solution was implemented because the ORCIDiD has become an internationally accepted researcher identifier, becoming a mandatory requirement for submitting papers for publication in a large number of international (and increasingly local/national) journals, and for applying for project funding with most international funders (e.g., the European Commission).

It has been noticed that many researchers have opened "empty" OR-CID profiles, i.e., profiles with only their surname and name, without any information about their affiliations and results. This is a lost opportunity because it represents them in international information exchange. It may not be as important for experienced researchers, but young researchers should certainly be educated on the importance of maintaining their profiles. The "Little ORCID Video School"[12] is certainly not sufficient for this, and steps should be taken to improve education for this activity.

## 6  Data about publications in eNauka

Each publication in eNauka is equipped and visible with all its PIDs, sources where it is available, and its citation in relevant sources (Figure 3)). Citations can only be tracked for publications that have recorded PIDs.

Among all PIDs, the DOI stands out because:

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11. Ministry of Science, technological development and innovation

12. Доступно на: Little ORCID Video School

**Figure 3.** Detail preview for results/publications

- Other PIDs (ScopusID, PMID, etc.) are automatically assigned based on it. A special application has been developed to add other PIDs without the need for manual input;
- It alerts to the correctness of the data in terms of the number of authors in the publication in eNauka and the number of authors assigned by the publisher when assigning the DOI and depositing metadata in CrossRef;
- It indicates the existence of duplicate records;
- It establishes a direct link to the landing page at the publisher's or aggregator's website, i.e., the one that assigned the DOI;
- It alerts to incorrect DOI assignment;
- It collects citations from open sources (OpenCitations);
- It checks the openness of publications for full-text access (UnPay Wall);
- It determines the mention of publications on social media (AltMetrics).

DOI has been applied in scientific publishing in Serbia since 2005, but only now have conditions been met for a comprehensive overview and the identification of problems that require resolution:

- A large number of publishers/providers (47) from Serbia deposit DOI and associated metadata in CrossRef. Each of them pays the same annual membership fee, which amounts to 275 USD;

− Even 26 of them deposit DOI only for one journal or proceedings, sig-
nificantly increasing the cost of individual DOIs;
− The deposited metadata in CrossRef is poor, i.e., it does not include all
significant metadata (e.g., ORCID for authors, project, licenses, cited
literature, etc.);
− Inconsistent deposition, i.e., a DOI is assigned to the publication, but
the metadata is not deposited in CrossRef.

Assigning DOI and its full-capacity application requires the engagement
of experts who know and regularly monitor changes in metadata standards
(CrossRef innovates them at least twice a year), as well as IT experts who
can implement these requirements. In Serbia, there are few of the former,
and the latter are expensive. This is recognized as the main reason for the
mentioned problems.

Direct links have been established for each entered PID to the service
where the PID was assigned, except in the case of ISSN, where the link
is established to the KoBSON service EleČas as the reference source for
researchers in Serbia, where the availability and category of journals are
checked.

For publications available in RPO repositories, links to each individual
repository are provided, enabling access to the full texts of papers. Of course,
access is only provided if the papers are deposited in the repository and ac-
cess is granted. The positive practice of establishing repositories in RPOs
in Serbia began ten years ago, but conditions for broader implementation
were only met in the middle of the past decade (Kosanović et al. 2019).
Credit for this primarily goes to motivated librarians in RPOs, as well as
decision-makers in institutions who recognized that repositories significantly
contribute to the visibility of published results and expressed readiness to
allocate financial (establishment and maintenance of infrastructure) and hu-
man (population of repositories, rule changes) resources for it. In 2021, 32
repositories (Đoković 2021) were registered in Serbia, but a more detailed
timeline graph is available at https://time.graphics/line/314977, which is
regularly maintained by Milica Ševkušić, a librarian at the Institute of Tech-
nical Sciences SASA.

Upon NITRA's announcement of establishing eNauka, many RPOs be-
gan (belatedly) establishing their repositories, and by mid-October 2023,
data from 111 RPOs were imported into eNauka, of which 107 have their
own repositories. The quality of data in these repositories is not the subject
of this paper, but it is up to the management of RPOs to decide what is a

sustainable solution and what is more cost-effective: paying for more modern IT solutions that require less manual work or a free solution with a lot of time invested in data entry. It is a positive fact that in Serbia, there is now a larger group of highly educated and dedicated librarians who have mastered all the intricacies of well-maintained repositories and are very involved in international initiatives/projects of the same purpose. The acquired knowledge will surely contribute to easier tackling of challenges expected in scholarly communications (e.g., preserving primary data, data management workflows, etc.).

Citation data are periodically retrieved in regular cycles from available sources using PIDs for each individual publication. This further means that if a publication does not have a PID in a service where citation tracking is conducted, then there is no data on citation. Additionally, citation tracking is only conducted in sources that have clearly (and transparently) displayed procedures for deduplication, sources from which they gather data, selection of sources for referencing, etc.

## 7 Training and end-user support

Quality of metadata about publications in eNauka is the responsibility of RPO editors, and special attention has been given to their education. Portal functionalities were gradually released to RPO editors starting from December 2022, and by April 2023, eNauka was fully operational for the University of Kragujevac, which had the most developed infrastructure. The experiences of RPO editors and researchers from Kragujevac were significant for the IT improvement of the process. In July 2023, eNauka was launched for all active researchers in Serbia.

Online (Zoom) training sessions for RPO editors were held in 5 sessions, and the entire recorded material is available to everyone at https://enauka. gov.rs/regres. Additionally, detailed instructions for work were provided. The following problems were identified:

- In several RPOs, researchers were appointed as editors who do not have sufficient knowledge about metadata and their exchange. In some cases, they perceived this as a degradation. According to the Law on Science and Research, RPO is obliged to have a "scientific-information documentation and library-information center," and it is expected that a librarian will work there. The fact is that in Serbia, there are more than 10 RPOs that do not have these. Neither a center nor a librarian. Only in one institution did we notice a change, i.e., they hired a librarian;

– Frequent changes of RPO editors, especially at the beginning, as decision-makers in science in their institutions (deputy directors or vice-deans) were appointed for this role by RPOs. Change is always good, but only if the newly appointed independently review the entire recorded material.

Researcher training was conducted exclusively through (1) recorded video tutorials and (2) instructions. In both cases, tutorials of different lengths were prepared (e.g., "Shorter is not possible" or "eNauka on one page"), but there are (rare) instances where even that was not viewed or read. By mid-October 2023, over 5500 researchers had logged into the system at least once.

User support was immediately established, but the number of people engaged in this activity changed. This is a necessary and binding service that must function because experiences from previously established systems indicate that this was a crucial drawback. Portals have good quality to operate 24/7, and users are inclined to utilize that quality. This means that a large number of eNauka users, especially researchers, log in during nights and weekends. Perhaps they do not expect a response during those periods, but if they receive one, they are certainly pleasantly surprised.

## 8  Conclusion and further plans

Establishing a national CRIS (Current Research Information System) is not a simple task, as if it were, it would have already been established. Time will tell whether NITRA's decision to finance the development of a national CRIS instead of subscribing to existing foreign commercial solutions was good or not. The result will only be measurable after a minimum of three years, but what is already visible is:

– Human capacity in RPO has been improved in terms of understanding the flows of scientific information;
– The number of repositories has significantly increased;
– Researchers' trust that they will not have to constantly enter their data from scratch has increased;
– Citations are collected from various sources, creating conditions for creating different indicators of success;
– Broad public accessibility contributes to data accuracy;
– Easier and faster rectification of identified deficiencies, and adaptation to domestic regulatory acts;

– Data collection from all domestic sources has been enabled...

For the next phase, expansion of eNauka to other entities important for the scientific research sector, such as projects and equipment, is planned.

Certainly, researchers and RPO editors play a key role in eNauka. If they accept the system without major resistance, the chance of success increases. However, the decision on the survival of eNauka is ultimately made by NI-TRA, in several ways: (1) providing institutional user support, (2) providing IT support and development in the same manner, (3) adapting regulations and rules, and (4) planning annual funds for eNauka.

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**Table 1.** An overview of various PIDs in eNauka. A share is calculated as a proportion of a total number for each entity.

| Entity | Acronym | Description | Proportion |
|---|---|---|---|
| **Istraživači** | ORCID | Open Researcher and Contributor ID | 83.28 |
| | E-CRIS ID | Researcher ID in eCRIS, or COBISS.SR | 98.03 |
| | APVNT | Researcher ID in Research Register of Vojvodina (KNR) | 25.26 |
| | IBI | Researcher ID - a connector to eNauka admin | 100 |
| | Researcher ID | Researcher ID in Web of Science | 754 |
| | Scopus ID | Researcher ID in Scopus | 17.43 |
| **Organizacije** | ROR | Research Organization Registry | 12 |
| | EC PIC | European Comission Participant Identification Code | 164 |
| | E-CRIS ID | Organization's ID in E-CRIS | 100 |
| | eNauka ID | Organization's ID - a connector to eNauka admin | 100 |
| **Rezultati** | DOI | Digital Object Identifier | 21.64 |
| | Scopus ID | Publication's ID in Scopus | 15.13 |
| | WoS_UT | Publication's ID PubMed | 2.68 |
| | PubMed ID | Publication's ID PubMed Central | 0.96 |
| | COBISS.SR-ID | Publication's ID in COBISS.SR | 31.21 |