IFMSA Policy Document
Open Science

Proposed by Team of Officials
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International Federation of Medical Students' Associations

Policy Statement

Introduction:
Open Science is a movement that gained significant traction among the scientific community during the 20th century alongside the spread of the internet and online dissemination pathways of knowledge. The need for it became apparent with the lack of transparency and reproducibility of research outputs, hindering the progress of scientific discoveries and their accessibility to scholars. Open Science has five main pillars: Open Access, Open Data, Open Education, Open Peer Review, and Open Reproducible Research. The Open Science movement can potentially increase scientific efficiency, democratize scientific knowledge, and increase the power of science to meet societal needs. To improve health care and continue their education, healthcare workers must have full access to high-quality research, regardless of language, financial, and geographic barriers.

IFMSA position:
The International Federation of Medical Students' Associations (IFMSA) acknowledges the importance of Open Science. It emphasizes that scientific knowledge should be transparent, accessible for all, reproducible, of quality, and with collaboration and engagement of the community. IFMSA emphasizes the benefits of Open Science and its contribution to achieving Sustainable Development Goals 3, 4, 10, and 17, as well as the importance in the field of Medicine and Health through ensuring accessibility and availability of resources to medical students and professionals from all backgrounds. The IFMSA highlights the need for structured dialogue and a collective and unified effort from the scientific community to ensure concrete progress in the transition to Open Science and therefore calls for all relevant stakeholders and parties to consider the implementation of Open Science in all relevant areas of their work.

Call to Action:
IFMSA calls on:

Governments and **Policy Makers** to

- Raise awareness among the relevant stakeholders and capacitate them on Open Science practices and their benefits to the scholars and the communities.
- Support developing the capacity and capabilities of all key education stakeholders to create, access, and use Open Educational Resources.
- Incentivize the development and research of Open Science through dedicated public funds, grants, resources, and exposure.
- Allocate resources to support scholars to make scientific articles, educational resources, and data accessible to all.
- Develop legal frameworks and guidelines for Open Science practices to ensure transparency, accessibility, reproducibility, quality, collaboration, community engagement, and innovation.
- Promote and support globally-shareable health data.
- Develop and adopt evidence-based standards, benchmarks, and related criteria accessible to all to ensure the quality of reproducibility in published research.
- Set guidelines and recommendations to increase Open Science accessibility and implementation.
- Enact policy to make publicly funded research free for the public.

Scientific Societies, Researchers, Research Institutes, and **Research Programmes** to

- Encourage and advocate the adoption of legal frameworks to support open licensing of publicly funded research and educational materials.
- Build awareness among relevant stakeholder communities on how Open Educational Resources can increase access to educational and research resources.

- Implement Open Science in their research, including publishing research outputs (data, papers, etc.) in Open Access journals.
- Make the health research and data open, available, and reproducible, allowing global cooperation towards better health status and more health development in different countries.
- Encourage implementation of the principles of Open Science to achieve global health.

Educators, **Universities**, and **Medical Education Organizations** to

- Utilize available licensed tools and resources and encourage their usage in ongoing/future research projects.
- Develop mechanisms to create communities that practice, use, and promote openly reproducible research.
- Promote, use, and adhere to the F.A.I.R Data principles in the data collection phase of research projects to ensure the reproducibility of research.
- Improve training on research and open science in the medical curriculum.
- Facilitate communication between students, researchers, and research centers to promote collaboration for Open Science projects.
- Offer medical students the opportunity to conduct research projects and publish them in Open Access journals.
- Advocate for and implement the principle of open education in health education.
- Promote international cooperation on health education through open sciences principles.

Students, **Students' Organizations**, and **IFMSA National Member Organizations** to

- Promote, use, and adhere to the F.A.I.R Data principles in the data collection phase of research projects to ensure the reproducibility of research.
- Collaborate with Universities, Medical Education Organizations, and other stakeholders to raise awareness and promote Open Science and its different pillars and values.
- Advocate for students to receive good formative research and Open Science education.
- Participate in different opportunities to enhance their knowledge.
- Advocate for quality research training that includes Open Science.
- Get involved in the publication of all scientific production carried out in Open Access scientific dissemination media.
- Raise medical students' awareness about the connection between open science and global health.

Civil Society Organisations and **Non-Governmental Organizations** to

- Promote and collaborate with other organizations to raise awareness about the importance of Open Science.
- Advocate for the shift towards Open Science practices in research, including data sharing, benefit distribution, and the promotion of diversity, inclusion, and equity in the research process.
- Advocate for using open principles as essential tools and values to ensure global health.
- Provide the public with accessible Open Science resources and tools.
- Raise awareness for the benefits of Open Science and include it as an agenda item in relevant forums.
- Motivate a global environment that allows sharing of research, health data, and health education sources.

Health facilities and **organizations**

- Promote and collaborate with other organizations to raise awareness about the importance of open science in achieving global health.
- Adopt the principles of open science to promote inter-organizational cooperation and reduce inequalities in health.
- Make the health data open and usable for more health development globally.

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Position Paper

Background information:

Open Science (OS) is a movement that emerged during the 17th century, with the first scientific journals aiming to disseminate research outcomes with scrutiny, skepticism, and open communication. [1] Later on, it came to the forefront in the 20th century as access to the internet became widely available, and online publishing required access to scientific data and the possibilities of new technology.[2]
Since then, multiple Institutes and Organizations, such as the Open Society Foundation (1993) and the Public Knowledge Project (1998), were formed to support this movement and contribute to its achievement. Recognizing its multiple benefits, in 2021 United Nations Educational, Scientific and Cultural Organization (UNESCO) released the "UNESCO Recommendation on Open Science," "an international framework for open science policy and practice that recognizes disciplinary and regional differences in open science perspectives." [3]
OS aims to make science accessible and free for everyone to use, irrespective of factors such as geography, gender, ethnicity, or financial background. This not only helps spread scientific knowledge, but also innovation, higher quality, and efficiency.

In the Medical Field, its importance came through during the pandemic, when many researchers and publishers adopted OS practices, as it helps improve economic cost and outcomes in health. Yet, current challenges:

- In 2015, over 50% of all publications were hidden behind a paywall.
- A pirating website for research articles, books and publications called Sci-hub hosts over 50 million papers. It provides access to an average of 164,000 requests daily, highlighting the global demand for open access.[4]

Discussion:

1. Definitions

Open Science has more than one definition. Our Literature search gave us these three most famous definitions.

- Open Science is defined as "an inclusive construct that combines various movements and practices aiming to make multilingual scientific knowledge openly available, accessible and reusable for everyone, to increase scientific collaborations and sharing of information for the benefits of science and society, and to open the processes of scientific knowledge creation, evaluation and communication to societal actors beyond the traditional scientific community. It comprises all scientific disciplines and aspects of scholarly practices, including basic and applied sciences, natural and social sciences and the humanities, and it builds on the following key pillars: open scientific knowledge, open science infrastructures, science communication, open engagement of societal actors and open dialogue with other knowledge systems." - UNESCO Recommendation on Open Science - November 2021[3]

- "Efforts by researchers, governments, research funding agencies or the scientific community itself to make the primary outputs of publicly funded research results – publications and the research data – publicly accessible in digital format with no or minimal restriction as a means for accelerating research" - OECD (Organisation for Economic Co-operation and Development) [5]

- "The movement to make scientific research, data and dissemination accessible to all levels of an inquiring society. The practice of science in such a way that others can collaborate and contribute, where research data, lab notes and other research processes are freely available, under terms that enable reuse, redistribution and reproduction of the research and its underlying data and methods" - FOSTER Plus (Fostering the practical implementation of Open Science in Horizon 2020 and beyond, EU Funded Project) [6]

2. Pillars of Open Science

Open Science knowledge (Open Access, Open Data, Open Education/Open Educational Resources, Open peer review, Open Reproducible Research)

The previously discussed values are primarily considered the foundation on which the pillars of Open Science work and target their processes. It showcases the cohesiveness and impact-oriented nature of the Open Science movement. According to the FOSTER Open Science Taxonomy, The following are some of the Pillars of Open Science:

2.1 Open Access

The open access (OA) movement has existed for over two decades. Starting with the Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities, which defined the movement, open access has now evolved, slowly gaining popularity within the academic community. The main goal of open access is to provide publicly accessible information online, to everyone, without charge and with few restrictions on repurposing. For authors (whose work is seen by more people), readers (who may access and expand on the most recent work in the area), and funders (whose work has a more significant impact since it can reach a wider audience), the free distribution of research is incredibly crucial. [7]

Open access (OA) journals employ alternative financing sources to publish their articles and disseminate their information for free. The main source of financing for professional open access publishing is now publication fees or article-processing charges (APCs)[8]. The author, the author's university, or the organization that funds their study will frequently pay this publishing cost.[9] For researchers from LMIC who typically experience financial restrictions, shifting the expense of academic publishing to the author may not be appropriate. Although some OA publishers provide complete or partial APC exemptions to researchers from LMIC, this is not always the case; for instance, most journals that need an APC do not include India in their list of eligible countries.[9] Due to their lower currencies, third-world nations are unable to pay APC since doing so would be extremely expensive for a single researcher working without institutional backing. Therefore, they are harmed by disclosing their significant contribution.[9]

There are three main routes to open access: the "Gold," the "Green," and the "Diamond" (or "Platinum," depending on the source) routes. The "Gold" route aims to make the final version of an article free and accessible to everyone upon publication, while the authors retain the copyrights. Those articles can be found either in fully OA journals or hybrid ones. The "Green" route, also known as self-archiving, uses a repository where a version of an author's article is placed, making it freely available to everyone. Unlike Gold OA, these items are typically copyrighted by the title's publisher or company associated with the title, with restrictions on reuse. Each journal or publisher has individual self-archiving guidelines that set

terms of use. [10] The Diamond OA aims for the article to be accessible on both ends, meaning authors and readers do not have to pay fees without losing academic quality.[11,12]

Medical research is essential to reach all parts of the world quickly and efficiently to make the medical practice evidence-based and benefit the patients. Open access is especially beneficial for underdeveloped nations where a lack of funding has previously prevented healthcare practitioners from accessing the most recent medical knowledge. More trustworthy medical information would help individuals worldwide prevent illness and enhance their health. Academics are also interested in OA since they are not compensated for writing in scholarly journals.[13]

It is important that open access is not gatekept by high open access fees, also known as article processing charges. High fees can result in only wealthy groups being able to offer their papers to a wider scientific audience, giving them further advantages in scientific competition and unnecessarily using research funds to pay for publications instead of research.[9,10,14]

2.2 Open Data

"Open Data is online, free of cost, accessible data that can be used, reused and distributed provided that the data source is attributed.".. Open data can first be defined as "data that can be freely used, reused, and redistributed by anyone - subject only, at most, to the requirement to attribute and share alike." This is explained in great depth in the complete Open Definition. The most significant points, in brief:

- Accessibility and Availability: The data must be accessible in its whole and for no more than a reasonable reproduction fee, preferably via internet download. Additionally, the data must be accessible and editable in some way.
- Redistribution and Reuse: The data must be made available under conditions allowing redistribution and reuse, including combining with other datasets.
- Universal Participation: There should be no discrimination against professions, individuals, or organizations; everyone must be allowed to utilize, reuse, and redistribute. For instance, restrictions on use for specific reasons (such as just in education) or "non-commercial" restrictions that would impede "commercial" use are not permitted. [15,16]

The current scientific ecosystem surrounding scholarly data publication prevents us from extracting maximum benefit from the research that takes place within and outside our communities, including its essential accessibility and reusability, which is why a set of guiding principles proposed by a consortium of scientists and organizations to support the reusability of digital assets, Known as the "F.A.I.R. data" principles were brought forth.[17]

F: (To be Findable) data are assigned a globally unique and persistent identifier
A: (To be Accessible) data is retrievable by their identifier using a standardized communications protocol
I: (To be Interoperable) data uses a shared, accesible, formal and broadly applicable language for knowledge representation
R: (To be Reusable) data is richly described with a plurality of relevant and accurate attributes
All of which, if correctly followed, helps bring Open Data closer to reality. [17]

2.3 Open Educational Resources and Open Education

Open Educational Resources(OER) are "digital materials offered freely and openly (without cost) for educators, students, and self-learners to be re-utilized for teaching, learning, and researching. The methodology of sharing said content is through educational materials organized as courses and typically distributed as pdf files. The content may or may not involve websites, simulations, text files, images, sound, or videos in digital format.[18]

The reasons to push institutions to use, produce and share OER vary significantly and generally include "basic technological reasons," "economic reasons," "social reasons," and "legal drivers," all of which can be seen from multiple perspectives of both the scholars and the stakeholders.[18]
OER has shown to have made significant advances in recent years in medical education, as the use of OERs is considered widely as students transition into clinical practice, with a high percentage of residents and program directors using a combination of wikis, e-textbooks, and podcasts to document, share and discuss unique findings. [19]

The public has a justifiable vested interest in ensuring that publicly funded research is free to the public. There are examples of countries with high research output, such as the United States of America, enacting policies that require publicly funded research to be free to the public. This trend should continue on a global scale for the ethical use of resources.[20,21,22,23]

2.4 Open Peer Review

Open Peer Review (OPR) needs a more precise definition and a consensus on the features and implementations that make it up. This is reflected in the literature, which contains multiple overlapping and incoherent definitions. While for some, the phrase refers to peer review where the authors' and reviewers' identities are made public, for others, it denotes systems where reviewer reports are made available with papers. For some, it denotes both of these circumstances; for some, it defines systems in which people other than "invited experts" can offer their opinions. It consists of numerous combinations of these and other cutting-edge techniques for others. [14]

When examining the various definitions of OPR, some core characteristics were revealing reviewer identities (open identities) and publishing reviews (open reports)[24]. Those main elements aim to tackle unreliability, inconsistency, and lack of accountability, among other problems that traditional publishing can cause. The idea that the reviewer's name would be publicly associated with a piece of work or that their review will be published motivates reviewers to be more thorough, which should result in better reviews. Additionally, open identities and reports can promote accountability by increasing openness and making conflicts of interest more instantly evident to writers and potential readers.[25]

2.5 Open Reproducible Research

Reproducible research refers to achieving the same results (e.g., tables, figures, numbers) reported in the paper using the same raw data initially gained and processing methods. Reproducibility is generally considered a minimum necessity for a finding to be believable and informative. Still, it is challenging to ensure due to the need for more sharing of the information required in published papers nowadays. In Open reproducible research, these materials are publicly available and accessible. [26]

The ability of doctors to guide patients regarding the benefits, harms, and costs of treatments and tests depends significantly on high-quality learning and guidance, which, in turn, depends on a robust evidence

base that is as complete and transparent as possible. Relying only on the results of published research and trial registries is unreliable as they often need to be completed and selectively reported.

Data sharing regarding reproducibility can significantly develop dissemination, meta-analysis, and understanding of research results; it can additionally assist in confirmation or refutation of research through replication, allow better implementation of research findings, and prioritize transparency regarding the quality and integrity of methods used. [27]

3. Open Science values, aims and benefits

3.1 Open Science values

The Open Science movement based itself on a solid foundation of values: transparency, accessibility, reproducibility, quality, collaboration, and community engagement. Collectively these values drive scientific innovation forward.

1. **Transparency:** Open access is a critical value that aims to make all scientific processes available to the community. That includes but is not limited to data, methods (materials, code, statistical analysis methods), and results (whether null or significant).
2. **Accessibility:** It emphasizes the importance of eliminating barriers preventing access to research, including but not limited to paywalls to access research articles & encourages the reuse of research output.
3. **Reproducibility:** One of the core values and the reasons for the shift towards OS. It refers to obtaining compatible results using the same data, methods, code, and statistical analysis steps made available and accessible. [28]
4. **Quality:** It is one of the concerns that supported the emergence of open research practices, allowing for better quality control and assessment and decreasing bias risks. [29]
5. **Collaboration:** OS fosters different types of collaborations within and outside the scientific community by eliminating barriers, increasing transparency, & breeding the share of knowledge and expertise based not on mere trust in the scientists but in the scientific process and scrutiny. [29,30]
6. **Community Engagement:** It serves the purpose of OS to build **trust** in research that fits the **needs** of the communities, including patients and their families, thus increasing the impact and public engagement in science. [31]
7. **Innovation:** By transparent collaborations among researchers and communities from different backgrounds and perspectives, OS promotes innovation and creativity. [32]

3.2 Benefits

The benefits of Open Science can be categorized into three broad groups: increasing scientific efficiency, democratizing scientific knowledge, and enhancing research capacity to solve societal needs.

Scientific Efficiency is defined as being able "to achieve more or better scientific outputs (i.e., findings, publications, trained scientists) using the same amount of scientific inputs (i.e., resources)." [33] The improvement in efficiency is explained by two broad mechanisms: (a) wider accessibility and availability of scientific knowledge resources (b) more interconnected, interdisciplinary, and seamless collaborations which drive creativity and innovation. [34]

A second benefit of OS, **Democratizing Scientific Knowledge**, is attained by increasing access to scientific resources, enabling broader community participation in the research process, and making

science more understandable to the wider population, including our patients. A study by the WHO found that 56% of institutions in the lowest-income countries had no access or subscriptions to international journals, thus limiting their access to the latest knowledge. [34] Hence, by decreasing the costs of accessing and reusing research output, OS decreases knowledge production and consumption inequality, leading it to democratize scientific knowledge.

Thirdly, OS aims to improve **research capacity to solve Societal Needs**. It does so through 3 mechanisms. First, OS helps increase ***visibility***, mostly noticed with marginalized groups better equipped with knowledge resources to negotiate to solve their problems.[35.36] Second, by promoting ***community and patient engagement***, the research agenda could be better guided toward solving problems affecting that group. [35,37] Last but not least, the open availability of licenses such as Creative Commons prevents the creation of barriers hindering the process of turning scientific knowledge into concrete solutions to local problems by that solving what is known as "the ***Tragedy of the Anti-Commons***" and promoting worldwide collaborations.[38,39] One of these fields of experimentation is open-source drug discovery which focuses on creating open knowledge resources free to use. Examples include Open Source Malaria [40], Open Source Drug Discovery [41.42] Malaria Box [43], etc. Interestingly, most of these initiatives aim to produce drugs for tropical diseases "where economic rewards are low and not enough for large companies to get into business." [33]

Regarding how OS benefits governments, institutions and individuals. For Governments, OER widens the scope of participation in higher education by expanding access to learning. It promotes lifelong learning through the availability of materials for both individuals and governments and bridges the gap between non-formal, informal, and formal learning styles. Building a more robust and more compact learning community[18]

For Institutions and Individuals, the direct gains, such as publicity/reputation within the open community, can be utilized in various ways. Free sharing can help reach the market more quickly, gaining an advantage over competitors. Hence it can be suitable for economic or commercial purposes. The quality can be improved, and the cost of content development can be significantly reduced by sharing and reusing while building on the knowledge. [18]

4. Open Science and Global Health

4.1 Data access and open access to reduce gaps between low-income and high-income countries

In the last few years, the importance of more global thinking regarding health and its issues has become increasingly prioritized. Global health as a concept is becoming more and more prioritized in the last two decades, especially after the COVID-19 Pandemic.

The rapid development of information and science generation has led to massive transformations and developments in scientific research and scholarly publishing. However, such rapid development increased the gap between the research in low-income and high-income countries.[44]

Researchers in low-income countries need more access to scientific data. Access is needed to ensure the process of generating new biomedical research. In addition, it limits physicians and healthcare workers from staying updated in their field, indirectly reducing the provided healthcare quality. [45]

The financial burden is also a reason for increasing the gap. Researchers and healthcare workers in low-income countries need help to afford research journal subscriptions to stay updated.[46]

In addition, research institutions and libraries in those countries need to provide access to researchers in these countries, especially with the continuously increasing journal subscription costs. [44]

Low-income countries are more exposed to infectious diseases than high-income countries. However, most infectious disease data is being produced by researchers from high-income countries.[47] At the same time, the researchers and health practitioners have limited access to the relevant data that might help them understand more about such diseases and plan and give better healthcare to their patients.[44]

Open access and open science shall directly solve the increasing gap in medical scientific knowledge generation and access. [45] Open access shall provide the needed data for health practitioners from low-income countries to understand and treat diseases better. In addition, With more rising global health threats, we need participation from all countries. Unfortunately, this is not the case. Researchers from high-income countries are mainly reaching the majority of research output[45]

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4.2 Covid-19, the lesson

The COVID-19 pandemic is quite a clear lesson on the importance of open data and access in tackling global health issues.[48] The pandemic showed the benefits of open science in guiding global efforts in detecting new diseases, identifying the symptoms, finding possible cure protocols, and even controlling a global pandemic.[49]

4.3 OS for GH

Currently, new health data and knowledge are massively increasing. However, at the same time, global health challenges are also increasing and becoming more threatening. Hence, it's becoming a necessity to make health data openly accessible all over the globe. In addition, health data needs to be more appropriately stored and processed.[50]

Open data and open access shall provide opportunities for more data analysis leading to early detection of health challenges on local, national, and global health levels. In addition, such universal access to data shall increase the potential of health systems in identifying disease patterns, understanding diseases better, planning preventive strategies, and setting effective health policies. It shall contribute to better global health status and reduce the number of global health threats.[50]

Open science, open access, and open data should be the central values we adopt in the new decades, where we focus more on global health to unify the world of health researchers, health practitioners, and health systems worldwide towards global health.

5. Other contributing factors to OS

5.1 Open Science infrastructures

Open science infrastructure (OSI) is a set of services, protocols, and software designed to support the research lifecycle and encourage open science practices. The components of OSI include both virtual and physical shared research resources. The essential components of OSI are open labs, open science platforms, repositories for publications, research data and source codes, software forges, virtual research environments, and digital research services.[3]

OSI enables trusted access to sustainable services, systems, and shared research data across disciplinary, social, and geographical borders. Furthermore, it provides essential open and standardized services for managing and accessing data and publications and promoting community engagement.[3]

OSI's successful implementation necessitates stakeholder-driven infrastructure, interoperability, and non-discriminatory membership. Open science infrastructures should be non-profit and guarantee permanent and unrestricted access to the public to the greatest extent possible. To ensure that content in repositories is appropriately vetted, discoverable, and reusable by humans and machines, OSI should establish interoperable standards and best practices. The successful implementation of OSI also requires adequate funding, stakeholder engagement, and community-driven efforts to ensure responsiveness to changing needs and transparency in its procedures. [51]

5.2 Open engagement of societal actors

Open engagement of societal actors involves scientists collaborating with societal actors outside of the scientific community, making the scientific process more inclusive and accessible. Open science provides a platform for citizen and community involvement in generating knowledge and fostering dialogue between scientists and citizens. It includes actively engaging all stakeholders, including researchers, policymakers, industry, civil society, and the general public.[3]

Citizen engagement in science can occur through the involvement of non-professional volunteers in the scientific process, usually in data collection, but also in other phases such as quality assurance, data analysis and interpretation, problem definition, and dissemination of results.T. [52]

Citizen science offers numerous advantages, ranging from the acquisition of new competencies and personal development to the establishment of social networks. This approach facilitates generating new knowledge and resolving complex problems by fostering engagement between scientists and society.[53] Additionally, researchers benefit from improved efficiency, speed, and quality in their research endeavors. Furthermore, policymakers can benefit from insights provided by citizen science projects, which may allow for a better understanding of a given issue, ultimately improving public sentiment and support for the cause.[54]

5.3 Open dialogue with other knowledge systems

Open dialogue with other knowledge systems means engaging in a conversation between different knowledge holders that recognizes and values the diversity of knowledge systems and producers. It encourages the inclusion of traditionally marginalized scholars, improves inter-relationships, strengthens connections across different epistemologies, and acknowledges the rights of knowledge holders to earn a fair share of any benefits that might result from using their knowledge.[3]

Open dialogue with other knowledge systems also fosters openness, transparency, and inclusiveness, which allows new social actors to engage in scientific processes, including through citizen and participatory science, thus contributing to the democratization of knowledge, fighting misinformation and disinformation, addressing real-life problems, and promoting more involvement of non-professional scientists.

To implement open dialogue with other knowledge systems, it is essential to create a shared vision and mission, establish clear communication channels, and acknowledge and communicate the contributions of different knowledge holders. The exchange of ideas between each knowledge holder can be facilitated by creating opportunities for collaboration and interdisciplinary research, promoting more involvement of non-professional scientists, and encouraging citizen and participatory science.[55]

6. Barriers to the Implementation of Open Science

There are several barriers affecting the adoption of Open science involving the dimensions of open research data (ORD), open access (OA), open peer review (OPR), and research evaluation (RA). Based on the opinion of the scientific community, the following barriers were identified:

In terms of OA, it is difficult for researchers and their research to achieve a more significant impact; visibility and accessibility, workload, contradictory attitudes, and age are important factors. (a) Concerning institutional support, there are difficulties in promotion policies. For example, a training campaign can only be carried out without **funding**. [56] In addition, there is **no policy regulation** for high-quality access repositories, institutional procedures need to be more apparent, and there needs to be **incentive or support** to publish, resulting in a lack of visibility of institutional repositories. Other barriers to highlight are the **lack of an adequate system** that evaluates the requirements and obligations in the calls for articles, as well as the lack of commitment on the part of the editors. **Ignorance and confusion about rights**, publication costs, and lack of agreements with large publishing groups due to the lack of prestige of open-access journals, predatory journals, and the sustainability of the journal in an open environment are also barriers. [57]
Regarding the ORD and its barriers, it was identified that there is **competition** among researchers, differences between disciplines, fear of being questioned, and a high workload. On the institutional side, there need to be more **data policies** that ensure the participation of all actors, as well as coordination between them, financing, and support. Other problems identified are the **need for more practical knowledge** about data management, the difference in criteria on the same project, and bureaucracy. Regulatory frameworks in this dimension have an uncertain legal and ethical framework and economic interests involved. [57]

The barriers to changing the evaluation criteria in an OS environment, the **disciplinary difference** between researchers, the **lack of recognition** towards them, and **little commitment** from consolidated researchers stand out. [58] In terms of institutional support, there is **no political participation at all levels** and **no global approach**; there needs to be more consistency in the traditional system and a **high economic cost for evaluations** and subjectivity, highlighting the need for coordination between institutions. Finally, on the OPR, there are **no curricular or reputational incentives** for researchers due to public **scrutiny**, **peer conflicts**, and **coercive effects**. There is also a **need for more rigor in the incentives** for access to publication and better review process management. [57]

The aforementioned is related to a publication based on the survey of early career researchers (ECR) and discussions among members of the Global Working Group on Open Science; it was determined that RCTs play a crucial role in Open Science from pre-registration to publication of the study, but also face challenges in adopting these practices. These challenges include **a lack of training and education, time constraints, and restrictions or incentives**. Open Science practices were found to be low during the design and follow-up stage of the study, which can create "path dependencies" that reduce the likelihood of Open Science practices at later stages. Regarding pre-registration, they expressed limited knowledge and a low frequency of pre-registration. The most common problem identified was the **low implementation of Open Processes** due to a **lack of knowledge and limited use of open hardware** at the data collection stage. In the case of Open Data, it was determined that researchers are familiar with it and have even used it. Still, related barriers, such as ethical and confidentiality issues and institutional policies, discourage the publication of Open Data. Finally, a significant issue is the perceived **cost**

associated with open access (OA) publishing, as researchers interpret OA as a form of "gold" or pay-per-author OA, and there is generally no incentive to publish in OA. [59]

The Washington Leadership Forum emphasized the importance of encouraging researchers to adopt OS practices and public research institutions to experiment with and adopt OS practices. Among the most critical barriers to adoption are **researcher uncertainty** and **institutional inertia**, as well as overly **restrictive intellectual property practices**, **misinformation**, and **outdated peer review standards**. The evaluation system that treats science only as a competitive game between individuals or research groups impedes the advancement of OS. Closed bibliometric data and anonymous peer review increase the concentration of the evaluative power of a few entities. There are also increasingly restrictive intellectual property rights and competitive attitudes of researchers within non-profit organizations. In for-profit companies, there is a commercial exploitation of intellectual property rights. [56] On the other hand, the development of open science policies is based on the Promotion of Transparency and Openness (TOP) guidelines, and some journals do not implement these policies or do not develop interventions to improve them. The reasons for this event are the need for more time, resources and authority to implement a change. [60]

7. Debunking Myths Around Open Science

Myth 1: Open Science leads to a loss of intellectual property rights.
To protect the ownership of intellectual property rights, open science is essential. Traditional publishing contracts sometimes demand that authors cede full rights, which restricts the dissemination and influence of their work. However, the SPARC Author Addendum enables writers to keep control of their articles' fundamental rights, enabling them to disseminate their research publicly. Authors may protect their rights while advancing knowledge by carefully reviewing publication agreements, negotiating fair conditions, and being aware of the worth of their intellectual property. Adopting open science helps to guarantee that research is accessible to more people and encourages good management of intellectual property.[61]

Myth 2: Open Science increases the risk of research misconduct and plagiarism.
Since both open science and research integrity work to protect the reliability and validity of research, they are inextricably linked. The concepts of ethics and appropriate research procedures are included under research integrity. It covers problems like fabrication, falsification, and plagiarism, which are regarded in the scientific community as significant misconduct. The goal of open science, on the other hand, is to increase the openness, accessibility, and reproducibility of research.
To prevent plagiarism and misconduct, open scientific approaches, including sharing research data, procedures, and analytic plans, are helpful. The scientific community may carefully review and validate the work by openly distributing research output, including methodology and findings. To keep researchers accountable and allow others to judge the reliability of the study, transparency is essential. It makes identifying dubious research techniques like selective reporting or data manipulation possible.
Additionally, sustaining study integrity depends on ethical research protocols prioritizing strict behavior. Some procedures include utilizing proven measuring tools, contacting statisticians, maintaining thorough records, and guaranteeing manuscript correctness. Researchers show their dedication to generating accurate and dependable data by following ethical research procedures.
Transparency, open science, ethical research procedures, and research integrity are all related and reinforced. Transparency and open science make disseminating and evaluating information more

accessible, and responsible research procedures help make it more reliable. Pre-registration and open data sharing are examples of open scientific approaches that increase openness and let others evaluate research methodologies and conclusions.[62]

Myth 3: Open Science lacks quality control and peer review.
Like traditional journals, reputable open-access journal articles go through the same peer-review process as those published in traditional journals.[63] Numerous Open Access journals of top quality are available. With an impact factor of 12.5, PLoS Biology is ranked first out of 86 journals in the biology category by the Journal Citation Report. BMC Biology is ranked #8 with an impact factor of 5.2. [64]More than 101 BioMed Central journals have official impact factors. In 2011, 21 journals reported their first impact factors. Of the 80 journals with existing impact factors, 53 saw an increase, while only 27 saw a decrease. The effect factor increased by 0.20 points on average.[65]

Myth 4: Open Science is too expensive and unsustainable.
Open research has the potential to result in long-term financial savings and productivity gains. Open science promotes co-operation and data sharing, makes research findings publicly available, and enhances the effectiveness of the research ecosystem. The essay outlines several types of research that have tried to evaluate the economic effects of open science. These studies use techniques including cost-benefit analysis, surveys, and interviews to quantify the worth and advantages of open research activities. Researchers can assess open data's utility and return on investment by gathering user information and comments. A cost-benefit analysis assesses the total costs and advantages within specific systems or sectors by combining survey data with desk research.

Additionally, using modeling techniques, several studies evaluate the impact of open research on technological advancement and economic growth. While case studies are frequently used to provide empirical evidence, these examples show specific situations when open research initiatives have had a positive impact. The potential for significant value creation in industries including education, healthcare, and transportation has also been demonstrated by more extensive economic evaluations. Open science increases research process efficiency by enabling information interchange and offers the possibility for cost savings by preventing duplication of effort and encouraging innovation.[66]

Myth 5: "Open Access is just a way for libraries to save money by shifting the cost of scholarly publications to authors and funding agencies":
Several OA journals do not charge APCs since academic institutions or learned societies finance them. Furthermore, many journals that charge APCs frequently waive them entirely or partly if the author has financial difficulties. The funding organizations or the authors' institutions occasionally pay the open-access APCs.[67]

Myth 6: Open Science is too complex and time-consuming for researchers.
Though it can need some modifications and early work, embracing Open Science methods eventually improves research efficiency, co-operation, and effect. Research procedures are streamlined by open science tools and platforms that enable data sharing, version control, and collaborative workflows. An increasing number of resources, groups, and other tools are also available to help researchers embrace Open Science principles (explained in the section "*Open Science Initiatives*" of this document).[68]

Myth 7: Open Science devalues the role of academic publishers.

Open Science does not diminish the significance of academic publishers. It acknowledges the value of editorial skill, quality assurance, and research dissemination. Open Science promotes programs that assure sustainable publishing methods while enhancing the accessibility and impact of research, and it encourages publishers to embrace open access models.[3]

8. Open Science Initiatives

Different policies have been put into place by **governments** worldwide to encourage and promote open science. Here are some examples of laws that governments have adopted to support open science, while the specific laws may differ between nations:

- **Open Access Requirements:** Governments have established regulations requiring that publicly financed research be made freely available. These regulations call for publishing research outputs, such as journal articles, in open access journals or repositories. The United States (e.g., the NIH Public Access Policy)[69], the United Kingdom (e.g., the Research Councils UK Open Access Policy)[70], and various European nations under the Plan S initiative are just a few examples of nations having similar policies.

- **Research Data Management:** Governments know the significance of maintaining and disseminating scientific data. Policies have been implemented to encourage researchers to manage and share their research data in open repositories while adhering to specified formats and metadata. Some governments offer policies, resources, and infrastructure to promote data exchange and management, encouraging openness and verifiability. For instance, the Horizon 2020 initiative of the European Union contains data management and exchange specifications.[71]

- **Infrastructure for open science funding:** Governments contribute financing for creating and upkeep the network of repositories, data centers, and collaborative platforms that support open science. The creation and upkeep of platforms that enable data-driven research, foster collaboration, and permit open sharing of research results are supported by this grant. Examples include the funding for research infrastructure provided by the Canadian Foundation for Innovation[72] and the European Open Science Cloud initiative.[73]

- **Research Institutions' Adoption of Open Science Policies:** Governments support adopting Open Science policies and practices by research institutions. They provide institutions direction and incentives to create rules supporting open access publication, data management, and team-based research. Governments frequently work with institutions to develop best practices and oversee policy application. For instance, the Netherlands' National Plan Open Science encourages educational institutions and research institutions to create their own Open Science plans.[74]

- **Open Science Training and Education:** Governments fund educational programs and training efforts to improve researchers' knowledge of Open Science methods and concepts. They offer tools and assistance to create capacity in areas like data management, open-access publication, and collaborative research. The Australian government's National Collaborative Research Infrastructure Strategy (NCRIS) involves funding for training and skill advancement in open science.[75]

- **Collaboration and International Co-operation**: To advance Open Science internationally, governments work together internationally. They participate in projects and collaborations promoting information sharing, harmonizing regulations, and creating common standards and frameworks for open science. An organization that brings together funding organizations from all around the world to discuss and coordinate open science policy is the Global Research Council.[76]

Several prominent non-governmental organizations (NGOs) have made significant efforts to advocate for and advance Open Science. Here are some examples of NGOs that have played a crucial role in promoting Open Science:

- **Open Society Foundations (OSF**): The Open Society Foundations support various initiatives promoting Open Science. They provide funding and support for projects that advocate for open access publishing, open data sharing, and open research practices. OSF has supported organizations and initiatives that advance Open Science, including the Public Library of Science (PLOS) and the Budapest Open Access Initiative.[77]

- **Public Knowledge Project (PKP)**: The Public Knowledge Project is an NGO dedicated to improving research's scholarly and public quality. They have developed and maintained open-source software platforms, including Open Journal Systems (OJS) and Open Conference Systems (OCS), which support open access publishing and conference management. Academic journals and conferences have widely adopted PKP's software to facilitate open and transparent publishing practices.[78]

- **Creative Commons**: Creative Commons is a global non-profit organization that provides free, legally standardized licenses for content sharing and reuse. They are playing a crucial role in promoting Open Science by offering licenses that enable researchers to openly license their works, including publications, data, and other research outputs. Creative Commons licenses are widely used in the Open Science community to facilitate open access and collaboration.[79]

- **FORCE11:** The Future of Research Communications and e-Scholarship (FORCE11) is a community-driven organization that aims to advance scholarly communication and e-scholarship through open and collaborative approaches. FORCE11 brings together researchers, publishers, librarians, technologists, and other stakeholders to discuss and develop innovative solutions for Open Science. They organize conferences, workshops, and working groups to address critical challenges and promote best practices.[80]

- **Research Data Alliance (RDA)**: The Research Data Alliance is an international organization that aims to accelerate data-driven research and innovation by fostering open data sharing and interoperability adoption. RDA brings together researchers, data professionals, and policymakers to develop and promote community-driven data-sharing standards and guidelines. They facilitate collaborations and provide a platform for sharing knowledge and best practices in Open Science.[81]

- **Confederation of Open Access Repositories (COAR):** COAR is an international association of repositories that supports the development, implementation, and enhancement of open access

repositories. They advocate for adopting interoperable repository technologies, promoting open access policies, and facilitating global collaboration among repository initiatives. COAR plays a crucial role in advancing Open Science infrastructure and practices.[82]

- **SPARC (Scholarly Publishing and Academic Resources Coalition)** is an alliance of academic and research libraries that advocates for open access, open education, and open data in the realm of open science. They strive to advance laws and procedures that enable open access to scholarly publications and educational materials and open sharing and reuse of scholarly data. To advance the concepts of openness and accessibility in research and education, SPARC works with stakeholders in the community, advocates for policy changes, and engages in collaborative projects.[83]

9. Students' Involvement in Open Science: IFMSA as an example

Students play a crucial role in promoting and contributing to Open Science initiatives. Their involvement helps advance scientific research and nurtures a culture of openness, collaboration, and transparency. IFMSA is a prominent example of a student organization that actively promotes and involves students in Open Science initiatives. IFMSA recognizes the importance of Open Science in advancing medical research, knowledge dissemination, and global health. Here are some initiatives in which IFMSA involves students in Open Science:

1. Research Exchanges: IFMSA organizes research exchanges and internships that allow medical students to participate in research projects worldwide. Students gain exposure to different research methodologies through these exchanges, collaborate with researchers, and contribute to ongoing studies. Students become familiar with Open Science principles and practices by engaging in research.

2. Open Access Advocacy: IFMSA advocates for open access to scientific literature and promotes using open access journals. They encourage students to publish their research findings in open access journals to ensure broad accessibility and impact. IFMSA also organizes workshops and campaigns to raise awareness among students about the benefits of open access publishing.

3. Open Science Policy Engagement: IFMSA actively participates in discussions and advocacy efforts related to Open Science policy development. They engage with international organizations, research funders, and policymakers to highlight the perspectives and needs of medical students in shaping Open Science policies. IFMSA contributes to developing inclusive and student-friendly Open Science frameworks by representing the student's voice.

4. Capacity Building: IFMSA supports capacity building initiatives to enhance students' knowledge and skills in Open Science. They organize training sessions, webinars, and workshops on data management, research integrity, and open access publishing. These activities empower students to engage in Open Science practices actively and become advocates for openness within their institutions and communities.

By involving students, IFMSA recognizes the potential of young researchers to drive change and innovation in the scientific community while fostering a culture of openness and collaboration.

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