Knowledge and practices of open science among scholars and researchers in Tanzania

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Abstract

The Open Science (OS) movement has been spreading rapidly among researchers with positive outcomes on accessibility of scientific knowledge. However, there is no clear evidence on the level of awareness and types of OS practices among scholars and researchers in Tanzania, potentially missing an opportunity to reap the rewards of the movement to scholarly pursuits. This study investigated the level of awareness of OS and practices among Tanzanian scholars and researchers.

Findings of a digital survey conducted for three months and recruited 144 respondents, show a high level of awareness of the term OS for 84% of respondents, most of them having encountered it from peers or online sources including social media. About 69% of respondents were male while about 44% of respondents were early career professionals. Open access (OA) publishing was the most common OS activity practised by respondents, highlighting both the need to create awareness on other practices and an entry point for knowledge expansion. However, respondents highlighted the barriers to spreading of the OS movement in the country including lack of awareness, knowledge and skills, the lack of institutional support and concerns over data security and ownership.

Findings of this study establish OA as the most common and important OS practice among Tanzanian scholars. They show the importance of online resources and peers to peer learning and in spreading OS awareness. The study also reveals several areas of advocacy and including setting supportive institutional policies and building infrastructure to support OS practices. We recomment establisment of robust guidelines, institutional support and clear opportunities to incentivize individuals to adopt OS practices ao as to achieve the momentum required to scale the movement beyond OA.

Keywords: Open Science, OS, Open Science Tanzania, Open Access

Abbreviations

APC	Article Processing Charge
ECRs	Early Career Researchers
Fig.	Figure
OS	Open Science
OECD	Organisation for Economic Cooperation and Development
OA	Open Access
OD	Open Data

Introduction

Open science refers to the movement that aims at making the scientific process openly available, accessible and reusable for everyone (UNESCO, 2021). The Organisation for Economic Cooperation and Development (OECD) defines Open Science (OS) as "efforts by researchers, governments, research funding agencies or the scientific community to make the primary outputs of publicly funded research results publicly accessible in a digital format with minimal or no restriction as a means for accelerating research; these efforts are in the interest of enhancing transparency,collaboration and fostering innovation" (OECD 2015).

The OS movement aims at maiing the research process more open and participatory for all relevant actors, within and beyond the scientific community (Dai et al. 2018). It encourages openness and transparency in research through collaboration and participation as well as an interactive relationship between researchers and citizens (Knack 2017). The movement seeks to extend principles of openness to the entire research process from idea generation, data collection, data analysis and findings communication with the goal of causing a systemic change in science and research conduct. The OS movement has succeeded to increase access to information and transparency in science globally although uptake has been slow in African countries, in particular in Sub-Saharan Africa, due to various socio-economic factors and low research funding (Mwelwa et al. 2020; Okafor et al. 2022). Considering the fact that scientific knowledge is a public good generated from public research that is funded by public monies, it follows that everyone should be able to access and make use of that knowledge at no additional cost thus generating higher social returns (OECD 2015).

In recent years, there have been various efforts geared toward advocating openness and transparency in scientific undertakings. As the world converges into a single village and science becomes a public good, it is only natural that science becomes open for scrutiny and validation by the public. OS makes it possible for the general public to access the scientific knowledge and processes by advocating for and providing the infrastructure to share scientific methods, output, data and research infrastructure. The rapid spread of the OS movement has been made possible through the advent of Information and Communication Technologies (ICT) that are increasingly integrating everyday life (Knack 2017). The internet and web applications have created new ways of generating knowledge, publishing and disseminating research output emanating from research projects and making them immediately available to the research, academic communities and the general public (OECD 2015).

OS is a relatively new avenue in the research landscape of Tanzania, with reported practices placing a heavy focus on open access (OA) (Dulle et al. 2010; Mgonzo & Yonah 2014; Buhomoli & Muneja 2022). OS adoption in Tanzania has been slow despite several initiatives geared towards promoting the movement (Muneja & Ndenje-Sichalwe 2016; Kaijage 2017; Siyao et al. 2017; Fossner 2021; Personal communication 2022; TCC Africa 2022). The slow

trend may be due to low awareness of the OS practices among research and academic institutions. Misconceptions and concerns for misuse of data such as loss of patent rights, data theft and manipulation in open repositories may hold back researchers from practising OS (Buhomoli & Muneja 2022). Elsewhere in Africa, a lack of clear institutional policies to guide application of OS principles has also been a hindrance and may be the case for Tanzania as well (Mwelwa et al. 2020; Okafor et al. 2022). Additionally, poor institutional support and incentives to promote OS adoption among researchers and unavailability of platforms for scientists in academia and research to practise OS may contribute to the slow growth . No comprehensive study on awareness of OS and practices in Tanzania has been conducted. Several studies have focused on few aspects of OA, particularly, open publishing/OA (Dulle & Minishi-Majanja 2009; Nunda & Elia 2019; Mbughuni et al. 2022). This study therefore, has established the level of awareness and practices of OS in academic and research institutions in Tanzania.

Materials and Methods

A cross-sectional digital survey of academicians, researchers, students, librarians and science communicators in Tanzania was done to assess their level of understanding and practice of OS. A semi structured questionnaire was used to capture demographic data and information related to OS practice in Tanzania. The questionnaire was disseminated as a Google Form (Appendix 1) and deployed by using social media platforms (Instagram, Twitter, Facebook, LinkedIn and WhatsApp), institutional mailing lists and to key individuals in institutions who could share it in their circles. Reminders were sent every 4 weeks and responses were collected for 3 months between December 2021 and February 2022.

A total of 144 responses were collected and exported as Google Sheets to Microsoft Excel where preliminary analysis was done. Further analysis was done in SPSS version 22.

Results

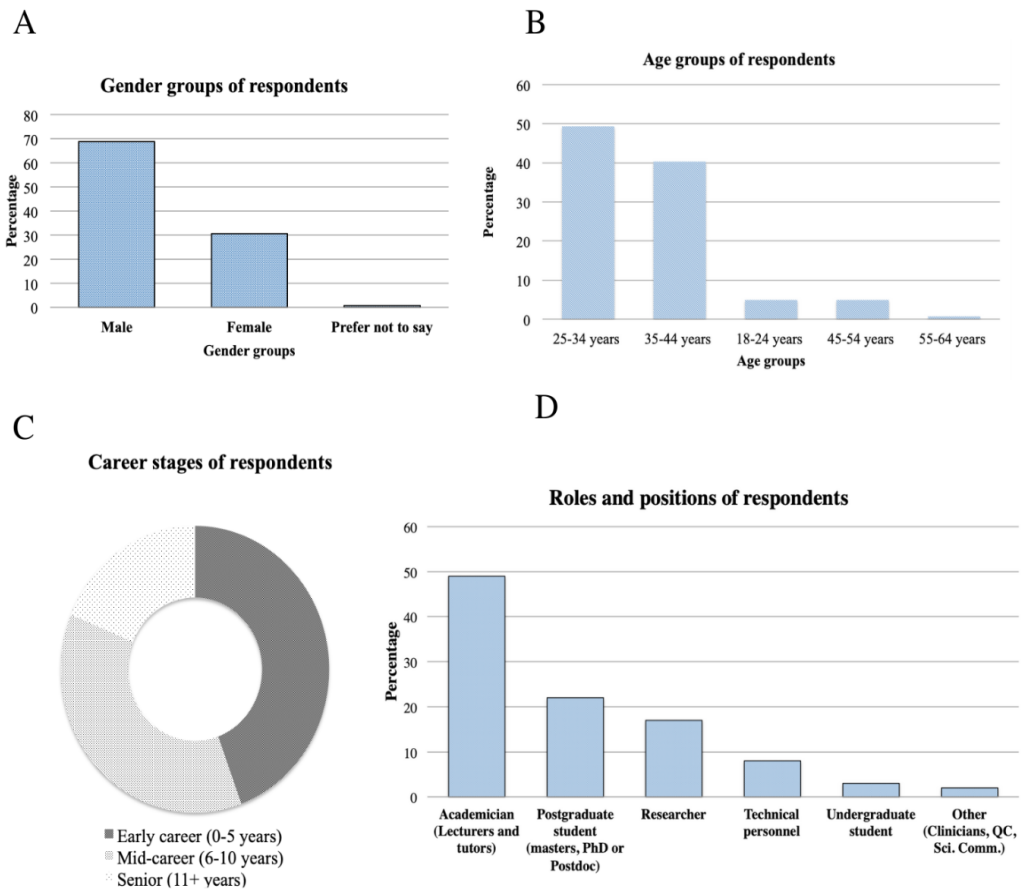
Demographics

The goal of this study was to assess the level of OS awareness and practices among Tanzanian scholars. The target audience were academics, researchers, students, librarians and science communicators as the groups more likely to practise open science.

A total number of 144 responses were collected via a digital survey, of which 68.8% and 30.6% were male and female respondents, respectively. About 1% of the respondents preferred gender anonymity (Fig. 1A). In addition, 49.3% of respondents were 25 - 34 year olds (Fig. 1B).

Early career respondents with 0 - 5 year experience were 44.4% while respondents in mid- and senior career stages made up 36.8% and 18.8%, respectively (Fig. 1C). Responding , academicians, postgraduate students and researchers were 48.6%, 22.2% and 16.7%, respectively. Less than 3% of the respondents were undergraduate students, communicators, clinicians and quality control officers (Fig. 1D).

Most respondents, 72.9%, were affiliated with public institutions and were mainly from the University of Dar es Salaam and University of Dodoma (Fig. 1E). Nevertheless, there were respondents from other academic and research institutions, public offices, regulatory bodies, science communication companies and non-governmental organisations (Supplementary Table 1).



F

Major institutions	Percentage
UDSM	26
Other	24
UDOM	17
Research institutions	8
Foreign	5
SUA	3
MUHAS	3
DIT	3
NM-AIST	3
MUST	2
SAUT	2
KCMU	2
MoCU	2

Fig. 1: Demographics of the respondents including gender distribution (A), age group (B), career stage (C) career roles (D) and institutional affiliations (E and F)

OS awareness

Regarding awareness of the term “Open Science”, 84% of the respondents said they were familiar with the term (Fig. 2A) with the majority associating it with sharing data, publications and methods (Fig. 2B). This is an indication that most of them have been exposed to OS practices and were the right target for the survey.

More than 50% of the respondents familiar with OS became aware of the term and/or practice mainly from their colleagues and social media or online sources. About 19% of the respondents learned about OS from the publishing process, 11.2% during their studies and 8.8% learned about it from other self-initiatives. Only 2.4% of the respondents had learned about OS from their institutional libraries. (Fig. 2D). Respondents also cited many benefits of engaging in OS in their research activities. The most common benefits were related to access and publication process. Responses citing improved access to publications, research methodologies and lower knowledge access cost, were 60% and 11.8% respectively (Fig. 2C). Respondents recognized that free access to others' works or publications had positively contributed to their research and gave them access to needed information. They also said it helped them share information to a larger audience and improved their visibility. It allowed accessibility to hundreds of research materials that would otherwise be difficult to obtain.

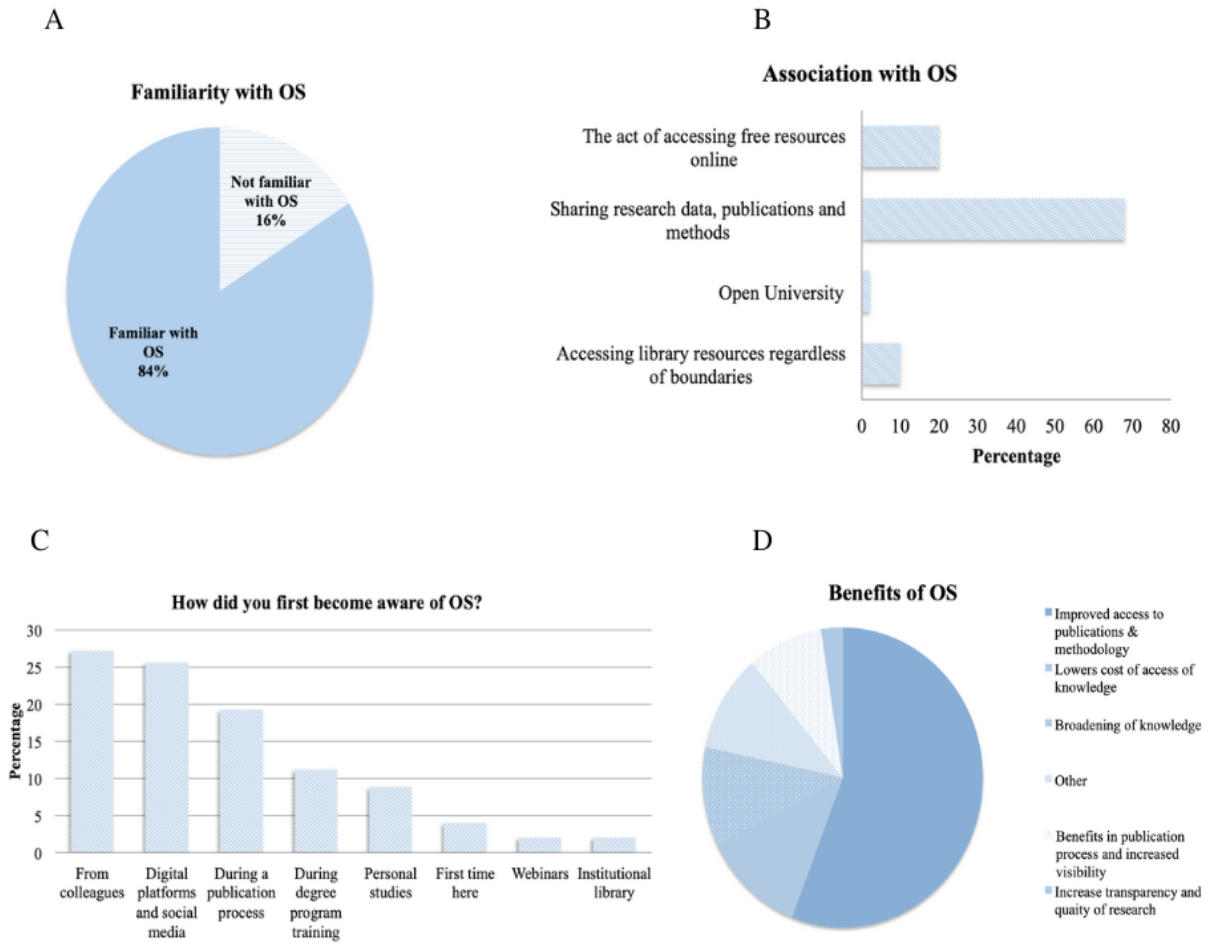


Fig. 2: Respondents awareness of open science (A) as well as what they associate it with. (C) shows how respondents first became aware of open science and (D) shows reported benefits of open science by respondents knowledge

Further analysis of the data showed that 72% of respondents who were aware of OS had practised at least one form; with 63.2% of them through OA publishing, 34.9% through open source activities and 31.1% via open data (OD). Others had practised OS via open notebooks and blogging (Fig. 3A). The remaining part of the respondents either had not engaged with any form of OS (15.3%) or were not sure if they had (12.5%). When inquired about their recent OS activity engagement, participants mostly reported activities related to OA publishing and OD activities. A handful of respondents used open notebooks and blogged about OS (Fig. 3B).

Further, OA publishing and sharing, and access of article and online information were reported as the most common OS activities among the respondents. Other common activities reported were OD and methodology sharing activities. A minority used institutional repositories and engaged in OS training and outreach activities (Fig. 3C).

This study therefore consistently shows that OA publishing and free access to scientific literature are the most common OS practices among the researchers and scholars (Fig. 3A, Fig. B and Fig. C).

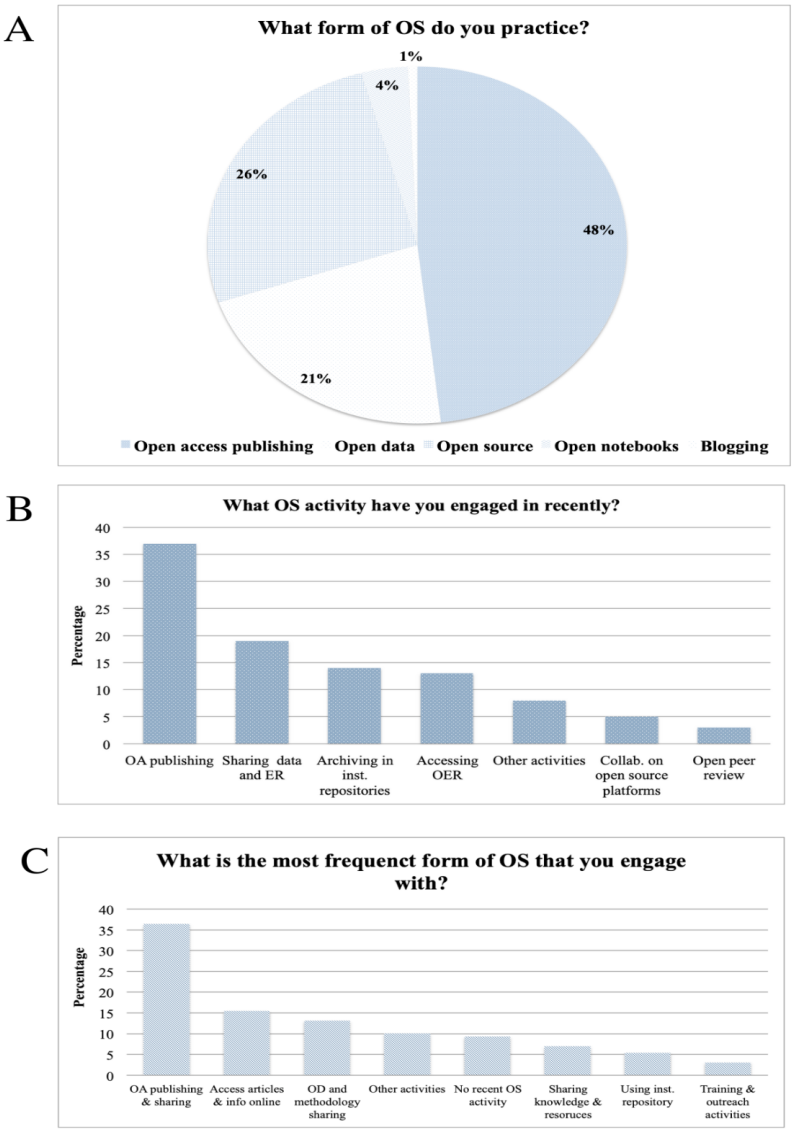


Fig. 3: Various activities practised by the respondents were aware of open science (A), most recent open science activities they had engaged with (B) and most common open science activities that respondents perform

When respondents were asked to name what the biggest hindrances to practising OS were, the most reported challenges were related to lack of awareness, knowledge and skills to engage with OS activities (41%, Fig. 4). Respondents noted that many scholars were not aware of OS practices and/or their benefits. They also said that scholars may lack necessary skills to adopt OS as some practices may require information technologies (IT) knowledge. Closely related to lack

of awareness were negative perception and the persistence of myths about OS such as those about quality of OA publications.

Another set of challenges were related to poor institutional support and unclear OS policies and guidelines (17%, Fig. 4). Here, respondents mentioned limited will to support OS at the institutional level and collaborating partners, lack of resources allocated to support OS, rigid institutional culture and lack of legal and ethical frameworks to support OS. The lack of OS policies at institutions was also noted, and when available, they were not known to the majority. It was noted that some academic institutions do not recognize academic works published in OA journals that charge APCs for academic promotion. This tended to discourage academicians from publishing their works in such journals. At the national level, the data sharing policy of Tanzania was reported as a problem although no further details were provided to specify why.

Technical challenges and infrastructural barriers were also not far off (13% of responses each, Fig. 4), where poor ICT usage knowledge and poor internet services were common themes. Other barriers reported to a lesser extent were related to financial limitations (6%, Fig. 4). Under financial limitations, respondents frequently mentioned lack of resources to pay for APCs as one of the barriers to practising OS. Further, shortage of funds to install OS infrastructure for students and scholars was also reported. Other challenges were related to copyright, legal and trust issues including the idea of not owning the copyright of data, poor legal and regulatory frameworks, fear of losing data, ownership of data and trust and perception on OS.

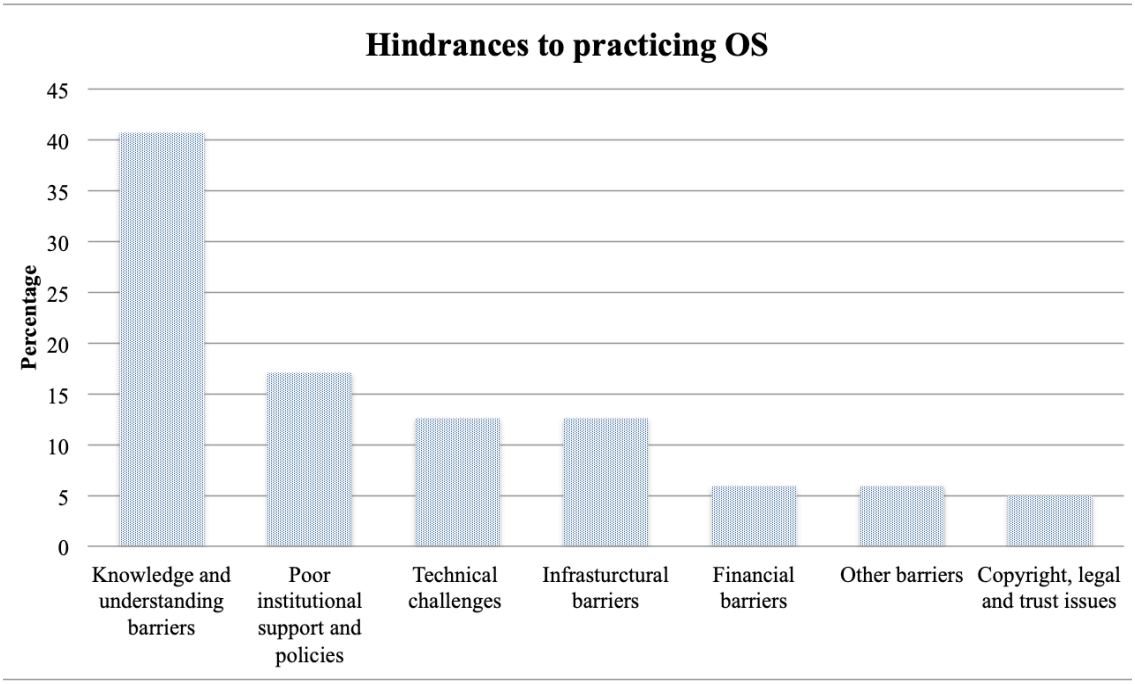


Fig. 4: Factors that act as barriers to practising open science in Tanzania

Discussion

This study aimed at understanding the level of knowledge and practice of OS among scholars and researchers in Tanzania. This is the first study of its kind as opposed to earlier studies that only focused on OA, institutional repositories and OD (Mgonzo & Yonah 2014; Samzugi 2017; Nunda & Elia 2019; Buhomoli & Muneja 2020, 2022; Kayungi et al. 2021; Mwalubanda 2021; Mbughuni et al. 2022). The results of this study are discussed below.

Demographics

Large part of respondents were early career researchers (ECRs) of 25-34 years old, probably reflecting the relatively recent adoption of the OS movement globally (Christensen et al. 2020) fuelled by the rise of ICTs but more so in Sub-Saharan Africa (Mwelwa et al. 2020). The respondents were mostly academics, postgraduate students and researchers affiliated to public academic institutions, our target groups. A study by Buhomoli & Muneja (2020) investigating awareness of OD among researchers in public universities in Tanzania observed similar demographics where the majority were males in early career stages. However, the majority of the respondents in that study were 36 - 45 years old, a different age group that observed here due to their work being more focused on academic staff, leaving other key participants like postgraduate students and other ECRs. Another survey study on OA scholarly in Tanzanian universities had the majority of the respondents above 41 years old (Dulle et al. 2010). However, that was because it purposely excluded junior academic staff and postgraduate students.

OS Awareness

Majority of respondents were aware of OS and correctly associated it with sharing data, publication, and methods. Interestingly, respondents familiar with OS first became aware of the term or practice mainly from colleagues, social media and other online sources. These routes indicate their potential as effective channels for creating awareness and encouraging OS adoption by capitalising on network effect. Other studies have reported the importance of both peer-to-peer learning and social media in advancing open science practices (Voytek 2017; Farrow et al. 2020; Zečević et al. 2020). They have highlighted that social media platforms such as Twitter and Facebook inform and create trends in open science and related fields such as data science. This observation may also explain the popularity of OS among ECRs since they are more likely to use social media for professional purposes (Nicholas et al. 2017; Jamali et al. 2020).

Several respondents learned about OS during their studies while a sizable portion learned during publication processes such as paying an article processing charge so that an article can be open. It seems like the majority of respondents became aware of OS through personal initiatives while a few respondents learned about it from their institutional libraries. Although best suited, there is indication that institutional libraries do not do enough to facilitate OS practice.

As awareness is the important first step in adoption of new technologies and practice (Ali et al. 2022), our findings set a precedent for promotion of adoption of OS practices in Tanzania. Further studies could explore which media, social media platforms and forms of peer-to-peer learning are most effective. Integration of peer-to-peer learning and social media may be a good strategy for spreading OS awareness and its advantages to scientists and the society at large. This could be coupled with scientific conferences and workshops that are regular avenues for science communication. These will enable scientists to meet and share their works and equip participants with hands-on skills on applying OS principles. Similarly, in their publication on awareness of OD among researchers in Tanzania, Buhomoli & Muneja (2020) recommended commemorating the World Open Data Day and Open Access week as a means to spread OS awareness.

There is also a need to integrate OS knowledge and practice into undergraduate and postgraduate curricula so that scientists acquire current knowledge and skills (Hagger 2022). In addition, clear institutional guidelines, policies and frameworks for practising and incentivizing OS will propel the trend and scale its impact compared to individual and small network effects.

OS Practices

Majority of OS activities reported by respondents were related to OA and publishing including journal selection, APC payment and self archiving in institutional repositories. OA publishing was reported as both the most frequently practised and recent OS activity that the respondents and colleagues engaged with. Respondents also engaged in activities related to OD, open source and open notebooks but at a much lower level compared to OA publishing and free access of knowledge and information. As noted above, OA is the dominant form of OS practised and researched in Tanzania, most likely due to the direct connection to promotion and career advancement of academics and researchers. Other studies such as that by Louderback et al. (2022) have also found OA to be the most common OS practice. There needs to be efforts to further awareness on other OS practices apart from OA. These other practices should be linked to the research process and clear incentives for uptake.

OS Benefits

Someone's knowledge of OS benefits can have an influence on their eagerness to adopt the practices. A large proportion of respondents cited easier and free access to information (scientific publications, methodology, datasets) and OA publishing as key benefits, commending on how they have impacted their research positively. They cited that OS, especially OA, led to lower research costs due to free access to information, which is a challenge for researchers and scholars in developing countries (Mwelwa et al. 2020; Okafor et al. 2022). Participants also mentioned other benefits of OS practices including increased visibility and chances of collaboration. The popularity of OA publishing and free access to information is linked to their direct incentives such as increased visibility and career advancement of researchers and academics (Swan & Brown 2004; Tennant et al. 2016; Mwelwa et al. 2020).

Challenges Facing OS in Tanzania

Individual and institutional challenges that create barriers to practising OS were observed. At the individual level, respondents' lack of awareness, knowledge and skills to engage with OS activities were the most common challenges. The lack of knowledge may have left room for perpetuation of fears over data ownership and copyright infringement, which were also reported by the respondents as barriers. In their study of authors perception of OA, Swan & Brown (2004) also noted that lack of awareness and wrong perceptions about OA journals were the main reasons why authors did not publish in OA journals. Therefore efforts towards increasing awareness of not only OA but also OS as a whole are needed.

On the institutional side, poor institutional support, unclear OS policies and guidelines, infrastructural barriers such as poor ICT capability and lack of internet access and financial barriers were cited. These barriers indicate that OS is not part of research culture and is not prioritised in the institutions respondents are affiliated with. The reported institutional challenges are not unique to Tanzania. In a review on institutionalising open science in Africa Okafor et al. (2022) mention insufficient funding, poor infrastructure, lack of deliberate policies and lack of OS awareness as the major roadblocks to advancing the movement in Africa. There is a need to strengthen human and technical institutional capacity to support OS practices across academic cadres as well as creating an enabling environment for promotion of OS.

Institutional support for OS in terms of comprehensive policies, guidelines and operating frameworks would help set tone for how other supporting organs such as libraries support OS practices. Institutions should also set aside resources needed to complement individual efforts in applying OS principles and incentives to make them impactful. In the end, OS practices benefit not only individuals but also boost ranking of institutions (Mwelwa et al. 2020). Several regional and country specific initiatives are changing the OS landscape in Africa including the African Open Science Platform (AOSP) (Participants of African Open Science Platform Stakeholder Workshop et al. 2018; International Science Council 2022) and Library Support for Embedded NREN Services and E-infrastructure (LIBSENSE) (LIBSENSE 2022). In addition, several countries in Africa already have OS policies or are in the process to adopt them, including Ethiopian, Congo, South Africa, Cote d'Ivore, Nigeria and Uganda (Tamrat 2021; Hey 2022; Oaiya 2022). Globally, OS advocacy has been growing with support from governments and major regional bodies. For example, the US government has mandated all agencies in the country to openly and freely publish all publicly-funded research by 2026 (Tollefson & Van Noorden n.d.) The OECD and the EU on the other hand have elaborate instruments for guiding open science frameworks and practices in member states (OECD 2015; EOSC Portal 2022; European Commission 2022). Further, the United Nations Educational, Scientific and Cultural Organization (UNESCO) adopted "Recommendations on Open Science" in 2021 to define shared values and principles for OS, identify concrete measures towards OS and provide an

international framework for OS policy and practice (UNESCO 2021). However, there are no clear policies and guidelines to govern OS and relevant practices. It is high time for Tanzanian institutions to actively partake in the OS movement and reap its rewards as well as contribute to the global scientific research agenda.

Conclusion

Open Sciences initiatives in Tanzania are fragmented and rely on individual drivers due to lack of policy frameworks that guides the OS implementation. This makes it difficult to have an effective and sustainable impact as well as changing the research culture in the country as a whole. As a consequence, OS and related initiatives are left in the hands of individuals, limiting widespread adoption and measurable impact of OS. Despite these shortfalls, the findings of this study have indicated a very promising level of awareness of OS among scholars and academics in the country. We recommend harnessing the power of peer-to-peer learning and social media platforms in addition to existing platforms to enhance OS awareness and practices. In addition, clear institutional support, provision of resources, incentives and frameworks will build on existing individual efforts to create a larger impact to both researchers and institutions.

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Supplementary figures

Supplementary table 1: The frequency of different type of institutions that respondents were affiliated with

Type of institution	Frequency
Public institutions	105
Private institutions	20
Foreign institutions	7
Other	7
NGO	5
Total	**144**

Author contributions

All authors took part in designing the study, data collection and analysis. ABD and PM prepared the first draft and all authors contributed to refining it.

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Competing interests

The authors have no competing interests to declare.

Appendices

1. Appendix 1: The survey

Questionnaire to assess understanding and practice of open science among researchers and academics in Tanzania

Background

Hello!

We are a team of Tanzanian researchers who would like to assess the knowledge about open science as well as the extent to which researchers and scholars in Tanzania practise its different aspects.

Open science (OS) refers to a movement aimed at making research output available and accessible to all levels of an inquiring society. This includes academic publications, data, physical samples, and software/digital tools. OS extends principles of openness to the whole research process to foster an environment that promotes sharing and close collaboration.

With this survey we hope to understand the level of understanding of different aspects of OS, extent of practice as well as motivations and challenges for doing so.

Section 1: Demographics features

Please provide necessary information that best describes yourself, your current role and the level of your experience in the research and academic environment.

1. Gender
    - Male
    - Female
    - Prefer not to say

2. Age range
    - 18-24 years old
    - 25-34 years old
    - 35-44 years old
    - 45-54 years old
    - 55-64 years old
    - 65-74 years old
    - 75 years or older
3. Institutional affiliation

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4. What is your current role?
    - Academician/Lecturer/Tutor
    - Researcher

- Technical personnel
- Administrator
- Postgraduate student (masters, PhD or Postdoc)
- Other

5. Years of experience in your role as per question 4 above:
   - Early career (0-5 years)
   - Mid-career (6-10 years)
   - Senior (11+ years)

Section 2: Awareness of Open Science principles

This section seeks to understand awareness of open science principles among researchers, academics and students in Tanzanian higher education and research institutions

6. Are you familiar with the term Open Science?
   - Yes
   - No

7. If your answer on question 6 is "Yes", what do you associate Open Science with? (choose most appropriate answer)
   - Open University
   - Open government
   - Sharing research data, publications and methods
   - The act of accessing free resources online
   - Accessing library resources regardless of boundaries
   - Other

8. How did you first become aware of Open Science?
   - Through exchanging information with colleagues
   - Through online sites and academic social media
   - During a publication process
   - Through personal studies
   - As my part of my course in degree programs
   - Through my institution library
   - Other

9. How do you benefit with Open Science in your research undertakings?

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Section 3: Practising open science

This section seeks to understand how researchers, academics and students practise open science

10. Have you ever practised any form of Open Science?
    - Yes
    - No
    - I don't know

11. If yes, which form of Open Science are you practising or have you ever practised?
    - Open notebook
    - Open access publishing
    - Open data
    - Open source
    - Other

12. In the list below, which one represents the most recent/current Open Science activity you have engaged with?
    - Archiving journal articles in an Institutional Repository
    - Involvement in an Open Peer review process
    - Collaboration in research using open source platforms
    - Submitting manuscripts in the open access journals for publication
    - Accessing Open Education Resources for teaching and learning
    - Sharing Open Education Resources online
    - Exchanging or sharing research data with colleagues
    - None of the above
    - Other

13. Which OS activities/principles are practised most by you and your colleagues?

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14. What do you think is the overall hindrance that limits Open Science practice among scholars in Tanzania?

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Section 4: General comments and suggestions related to open science in Tanzania

15. Do you have any comments regarding the policies, infrastructure and practising of OS in research and higher education institutions in Tanzania?

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