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RESEARCH ARTICLE

Developing Data Management Plans (DMPs) to Fulfil Funders' Requirements among Researchers in Higher Learning Institutions (HLIs)

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ARTICLE INFO	ABSTRACT
	The primary objective of this study was to explore how researchers can effectively create data management plans (DMPs) to meet funders' requirements. The data was collected from involved 206 postgraduate students from the Nelson Mandela African Institution of Science and Technology (NM-AIST) in Arusha, Tanzania, achieving a response rate of 104 (50%). A census sampling technique was employed to ensure equal representation among all participants, with data collected through structured questionnaires. Respondents recognized the importance of designing DMPs to meet funders' requirements in higher learning institutions (HLIs). However, a lack of proficiency and awareness in designing DMPs was among the major challenges. Most respondents indicated that they created a DMP before starting their research projects, with the open-DMP online template being a preferred tool among various DMP resources. A comprehensive DMP should clearly specify the data collection techniques used during the project. One of the key benefits of employing DMPs is the ability to document essential research project activities. HLIs should support researchers in creating DMPs to fulfil funders' requirements. By emphasizing the role of DMPs as a vital research component, researchers can enhance the quality and impact of their research outputs while ensuring compliance with data management standards and regulations.

INTRODUCTION

Effective management starts with a carefully crafted plan. This principle is equally true for higher learning institutions (HLIs); when researchers seek research funding, they must submit a detailed Data Management Plan (DMP) to funders. This plan outlines how they will handle their research data throughout its lifecycle. A DMP is a documented plan that is also required by funders to view how the researcher can utilize the fund in various research activities such as data collection, data analysis, and data archiving and preservation (Mosha and Ngulube, 2024). A DMP is developed using several components, such as metadata standards, access policies, and data archiving policies (Baykoucheva, 2015; Nightingale, 2020). It addresses considerations such as data protection, confidentiality, preservation, compliance with funders' requirements, ethical considerations, risk mitigation, research efficiency, reproducibility, and transparency (Gajbe, Tiwari and Singh, 2021; Hudson-Vitale and Moulaison-Sandy, 2019; Miksa, Oblasser and Rauber, 2021; Mosha and Ngulube, 2024; Smale et al., 2020). Bishop and Hank (2020) highlight that DMPs clarify the "what, how, who, and where" of research data management by formally defining roles, responsibilities, and activities conducted

throughout the research process. Generally, DMPs are concise, high-level descriptive plans that specify the types of data to be produced, data access permissions, secure storage methods, documentation and metadata creation practices, and long-term preservation strategies (Burnette, Williams, and Imker, 2016). HLIs can develop their own DMP templates to support their researchers when applying for research funds; however, they can also adapt and modify available online DMPs developed by other HLIs worldwide (Mosha and Ngulube, 2024). DMP can be prepared directly with word templates or with the aid of online tools (Gajbe, Tiwari and Singh, 2021).

Funders supporting research activities require a comprehensive Data Management Plan (DMP). For example, the National Science Foundation (NSF) mandated in 2011 that all grant application proposals should include a DMP (Van Loon et al., 2017). Also, in 2013, the Office of Science and Technology Policy called on all major federal funding agencies to ensure access to publications and data generated from federally funded research are well stated in a DMP (Van Loon et al., 2017). As such, other federal funding agencies, including the National Institutes of Health (NIH), the Department of Energy, and the National Aeronautics and Space Administration, now require or will soon require a DMP from researchers as a support for their application for funds (Van Loon et al., 2017). Funders should specifically state the required elements within DMP templates to enable researchers to comply before submitting their requests (Pharm et al., 2023). In the early days of requiring DMPs, the U.S. NSF reportedly felt the standard for content would emerge through the community of practice (Berman, 2017). Other funders, both governmental and private, in the United States (US) and around the world have come to adhere to the ethos of openness in terms of the data emanating from the projects they will fund; this mentality of supporting open access to the results of the sponsored research seem generally to be in concert with the interest in openness discussed in the introduction and as a mechanism to support the quality of research and support the scientific method (Hudson-Vitale and Moulaison-Sandy, 2019).

Funders review DMPs manually; however, they are guided by Findable, Accessible, Interoperable, and Reusable (FAIR) data principles (Pharm et al., 2023). Besides the criteria from funders, there is a need for guidelines on effective DMP practices from organizational funders and research institutions (Sallans and Donnelly 2012) that support DMP writing by institutional authorities (Diekema, Wesolek and Walters 2014). In the case of 'metadata', researchers need help from information professionals in developing and implementing their DMP. Some funders prefer DMPonline, while others may prefer DMP printed templates (Mosha and Ngulube, 2024). The University of Edinburg provides a notable example of a DMPonline template (https://digitalresearchservices.ed.ac.uk/resources/dmponline) through the Data Curation Centre (DCC) to enable researchers to create, review, and share DMPs that align with institutional and funder requirements (Burnette and Williams, 2016). The tools offer funder-specific DMP templates (e.g., NSF, 2018) or European Commission Horizon 2020 (European Commission, 2016). Most of the questions are open to the researcher and provide guidance depending on the chosen template and the research organization (Miksa, Oblasser and Rauber, 2021). Miksa et al. (2023) proposed methods that constitute a toolbox that can be used to build specific tools for automated machine-actionable DMP (maDMP) assessment that consider the exact constraints in which the tools will be used, for instance, reflecting specific funder requirements, or institutional policies or legal constraints. Miksa et al. (2023) plan to map these methods to popular funder templates to identify the possible level and kind of automation using Information Retrieval and Natural Language Processing (NLP) techniques to create further methods that better address the non-machine-actionable parts of maDMPs (Miksa et al., 2023). Researchers can customise these tools based on their research needs, accessing examples and guidance tailored to the University of Edinburgh's support and services (Burnette and Williams, 2016). They can also explore a growing list of public DMPs published by other tool users for inspiration (Burnette and Williams, 2016). Therefore, researchers worldwide

are increasingly mandated to develop and adhere to DMPs for their research projects to ensure the manageability and reusability of research data (Miksa, Oblasser and Rauber, 2021).

Funders' Requirements for DMP

Most funders worldwide require comprehensive Data Management Plans (DMPs) to ensure effective data management throughout the research process (Mosha and Ngulube, 2024). Miksa et al. (2023) explores methods to assess the quality of information provided in DMPs, focusing on the extent to which the decisions outlined lead to FAIR data (Wilkinson et al., 2016) and meet specific funder requirements. They developed two scenarios: TO-BE-1 and TO-BE-2. In TO-BE-1, researchers still use DMP Software to create their plans, but the software now sends a machine-actionable DMP (maDMP) to the funder for evaluation (Miksa et al., 2023). This software offers structured, human-readable information and metrics to pre-assess responses in the maDMP. To determine how well the maDMP meets funder requirements, a study by Miksa, Oblasser, and Rauber (2021) investigated DMP templates from the European Commission and a national funding body in Austria, examining their coverage. Funder services can use this information to evaluate the implementation of DMPs (Miksa, Oblasser, and Rauber, 2021). Pham et al. (2023) compare DMP evaluations for 21 funded projects using two approaches: an automated analysis to identify alignment with best practices in open research initiatives and a manual scorecard assessing the same criteria. Although the DMP is reviewed as part of each NSF proposal's intellectual merit or broader impact, requirements can vary slightly across NSF directorates (Van Loon et al., 2017; Abbas et al., 2024). The DMP as a Research Tool (DART) project, led by Rolando et al. (2015), developed and tested an evaluation rubric for NSF DMPs, creating a robust and standardized tool for cross-institutional comparisons. An early version of the DART rubric was utilized by Samuel et al. (2015) to assess 29 DMPs from Engineering faculty at the University of Michigan. This assessment revealed significant variability in the overall quality of DMPs. It highlighted common missing elements, such as clear roles and responsibilities for data management, metadata standards, and policies for protecting intellectual property rights. Some of the funders' requirements for DMP are stated (Table 1).

Table 1: Funders' requirements for DMP

Funder	Requirements for DMP
The Scholarly Publishing and Academic Resources Coalition (SPARC)	Explore the data sharing policies of U.S. government agencies. SPARC is a global organization dedicated to advancing open access, open data, and open education initiatives.
Funder guidelines (from DMPTool)	The DMPTool website offers links to the DMP requirements of various funding agencies and organizations, which are the basis for its DMP templates. It also includes links to funding proposal guidelines.
NSF Data sharing policies	NSF Directorates and Divisions provide discipline-specific guidelines to complement the agency-wide policies on data sharing and Data Management Plan requirements.
NIH Data sharing policy	The NIH has a current policy statement on data sharing, along with details on its implementation. Additionally, there are links to information about a new, more stringent policy that will take effect in 2023.
Current NIH Data sharing requirements	A list of existing data sharing policies at the NIH includes guidelines from the NIH itself, as well as those at the

	Institute and Center (IC), division, and program levels, applicable to a wide range of investigators and data sets.
NSF-DMP Requirements: As an Extension of the NSF Data Sharing Policy	Grant proposals must include a DMP of no more than 2 pages, outlining how all data generated from the research will be managed and deposited in a repository. Additionally, the data underlying research papers must adhere to publisher data sharing policies.
The National Endowment for the Humanities (NEH) Office of Digital Humanities	Mandates the inclusion of data management plans in grant applications for proposals and awards.

Statement of Problem

HLIs engage in research undertakings daily through their researchers, students, and staff personnel; however, not all of them are required to develop a well-stated DMP except those required by their funders. As most of these researchers apply for funds, there is a need to be able to design a DMP to fulfill funders' requirements and manage their research projects meaningfully. The lack of awareness regarding designing DMPs for researchers and HLIs in general (Mosha and Ngulube, 2024; Harith et al., 2024) and the absence of established DMP best practices within academia (Lefebvre, Bakhtiari and Spruit, 2020) have been identified as key obstacles contributing to applying DMPs among HLIs. On the other hand, failing to design a DMP based on the funder's requirement might make it difficult to design a data model that supports all kinds of questions from different DMP templates (Miksa, Oblasser and Rauber, 2021). Moreover, it has been noted that DMP guidelines often emphasise post-publication data sharing rather than activities that enhance data quality, ensure traceability, or facilitate reproducibility (Williams, Bagwell and Zozus, 2017; Jumaa et al., 2024). Another factor affecting attitudes toward DMPs, and the end-goal of data sharing is the mixed messages that funders might send. Dietrich et al. (2012) reviewed funding organizations and found varying disjointedness of coverage in data management policies concerning storage, licensing, metadata, and sharing. The present study explores the significance of DMP in HLIs, focusing on how researchers can be able to develop and use DMPs, outlining the necessity of DMPs before, during, and after research, recommending DMP template tools, outlining the elements of comprehensive DMPs, as well as discussing and benefits and challenges associated with developing DMPs among researchers in HLIs.

Research Objectives

The primary objective of this study was to investigate how researchers can effectively develop DMPs to meet funders' requirements. The specific objectives included:
1.   To assess the benefits of DMPs in fulfilling funders' requirements.
2.   To identify DMP template tools required by various funders.
3.   To explore the essential components and principles for developing a comprehensive DMP
4.   To evaluate the benefits of DMPs for meeting funders' requirements.
5.   To examine the challenges faced by researchers in HLIs when developing DMPs.

MATERIALS AND METHODS

A quantitative cross-sectional research study was conducted at the Nelson Mandela African Institution of Science and Technology (NM-AIST), a research-focused public university in Arusha, Tanzania. NM-AIST consists of four schools: namely the School of Computational and Communication Science Engineering (CoCSE), the School of Materials, Energy, Water and Environmental Sciences (MEWES), the School of Life Sciences and Bioengineering (LiSBE), and the School of Business and

Humanities (BuSH). The School of BuSH was not included in this study due to the absence of any postgraduate degree programs during the data collection period. The study employed a census sampling design (Drechsler and Reiter, 2010) to select study participants, with all postgraduate students having an equal opportunity to participate. A total of 306 postgraduate students were included in the study. Data collection was performed using structured questionnaires, and data analysis was carried out using IBM SPSS Statistics® 29.0.2 software.

RESULTS

Demographic Characteristics

Out of the 306 questionnaires distributed to respondents, 104 were returned, resulting in a response rate of 34%. A total of 55 (53%) were male, and the majority fell within the age range of 21 to 30 years. Regarding their academic pursuits, a total of respondents 64 (62%) were pursuing master's degrees, while 40 (38%) were enrolled in PhD programs.

Benefits of DMPs in Fulfilling Funders' Requirements

The necessity of DMP was acknowledged by respondents 101 (97 %). When asked about the reasons for these benefits, a total of respondents 31 (30 %) cited compliance with funders' requirements. Figure 1 illustrates the benefits of fulfilling funders' requirements
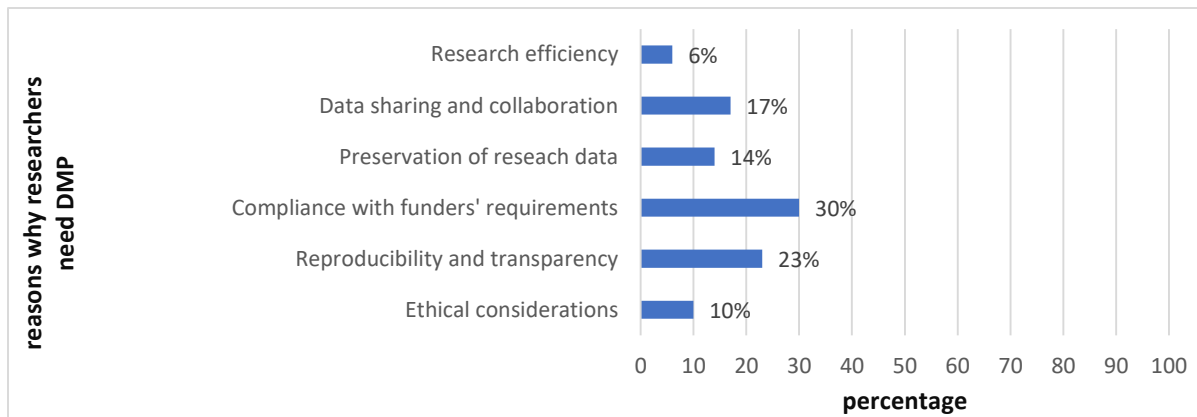

Figure 1: The benefits of DMP in fulfilling funders' requirements

A total of 45 (43%) respondents developed a DMP before beginning the process of writing their research. Figure 2 explains the period necessary for developing a DMP.
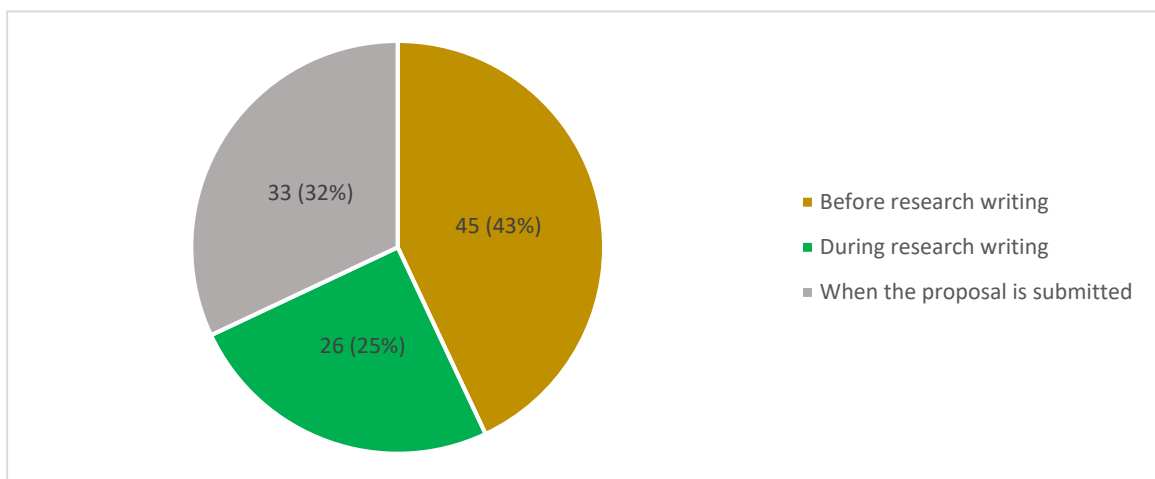

Figure 2: The DMP development period

DMP Template Tools Required by Various Funders

Out of 104 (100%) respondents, a total of 70 (67.3%) respondents didn't use any DMP template tool, while 34 (32.7%) respondents used the DMP template tool when applying for research funding from various funders. In contrast, a total of 20 (21%) respondents used DMP word template tools, and 13 (13%) used DMP online template tools. These findings are well illustrated in Figure 3.
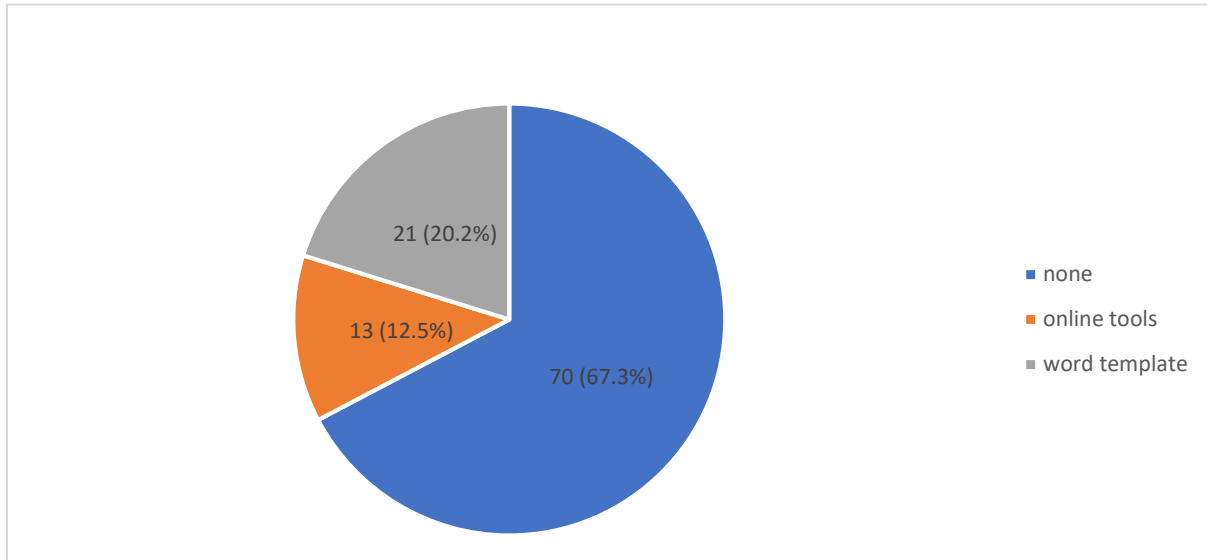

Figure 3: DMP template tools among researchers

Additionally, a total of 51 respondents (49%) chose open DMP as the most preferred DMP online template tool favoured by most funders for research funding applications. Figure 4 illustrates various DMP online template tools for funding applications.
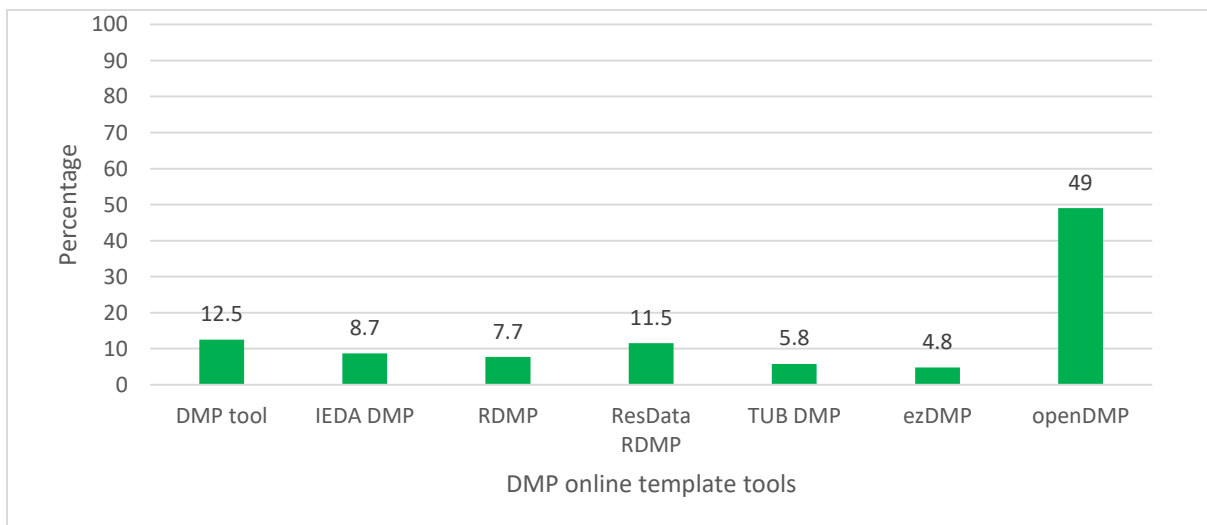

Figure 4: Various DMP template tools
**Essential Components and Principles of a Comprehensive DMP**

A total of 31 (29.8%) respondents believed that a complete DMP should incorporate a data type to be collected. On the other hand, a total of 20 (19.2%) respondents emphasised the importance of a clear, specific, and detailed DMP. Table 2 explains the essential components of a comprehensive DMP.

Table 2: Components and principles of DMP among researchers in HLs

Characteristics	Frequency	Percentage
Component for DMP		
Availability and accessibility of data	9	8.7
Data, format and standard	25	24
Guidelines, procedures and policies	6	5.8
Intellectual property rights	10	9.6
Long-term preservation and archiving	5	4.8
Methodology and processes	18	17.3
Type of data	31	29.8
DMP principles		
adhere to requirements	14	13.5
clear, specific and detailed	20	19.2
Feasible	8	7.2
Justified	12	11.5
not verbose	2	1.9
optimal use	4	3.9
Relevant	10	9.6
short to point	27	26
standards of practices	7	6.7

Benefits of DMPs for Meeting Funders' Requirements

A total of 30 (28.9%) respondents mentioned that DMPs enabled them to document the key activities of their research projects. Further benefits of DMPs are illustrated in Figure 5.
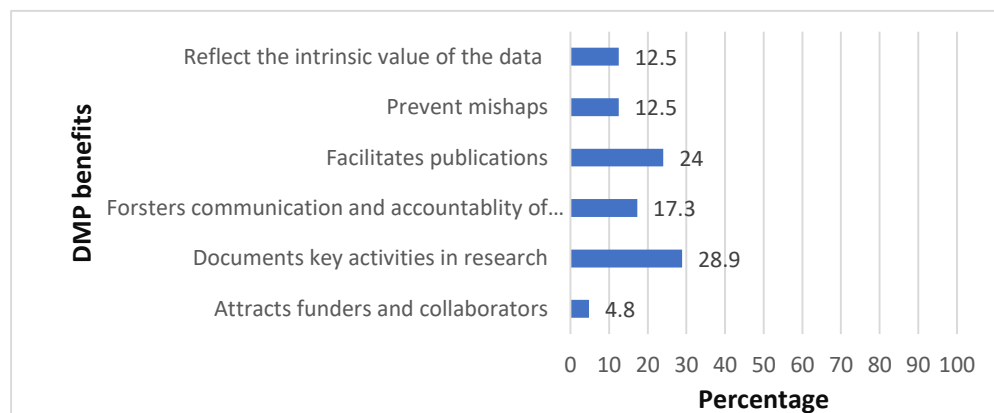
Figure 5: Benefits of DMPs for Meeting Funders' Requirements

Challenges of Using DMP among Researchers in HLIs

A total of 28 respondents (26.9%) reported a lack of competency and awareness in developing DMPs. Additional challenges are illustrated in Figure 6.
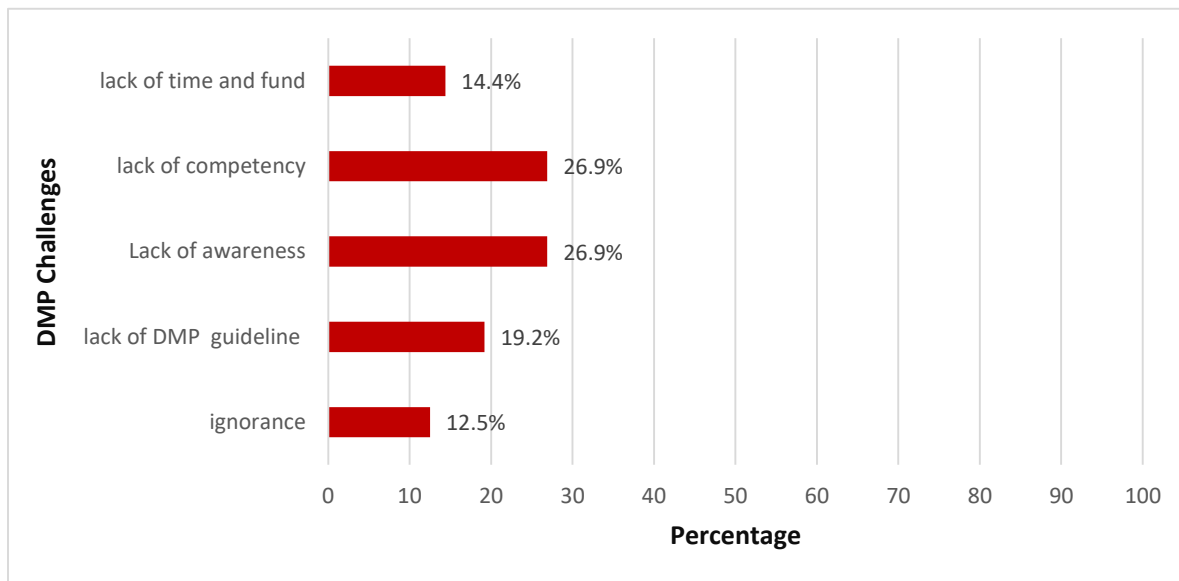

Figure 6: Challenges of Using DMP among Researchers

DISCUSSION

Respondents acknowledged the significance of developing DMPs in meeting funders' requirements. The same observation was noted by Smale et al. (2020). However, Miksa et al. (2023) pointed out that writing and designing a DMP does not have to be considered only from the perspective of fulfilling funder requirements since DMPs can also be used or mandated in other settings. For instance, developing a DMP can be an internal requirement within HLIs for students as a guide for their research projects. However, this argument was not agreed upon by Mischo et al. (2014), who examined 1260 DMPs at the University of Illinois and found no significant association between data storage methods and proposal funding success, although they discovered an increasing reliance on their institutional repositories as a venue for research. Therefore, in most cases, DMPs are crucial for meeting the requirements of funders and institutions, serving as essential tools for planning data-driven research projects and ensuring long-term access and usability of research data and digital objects (Pham et al., 2023). The U.S. NSF began mandating DMPs in 2011 by providing the elements required when developing a DMP for funds applications (Pham et al., 2023). Additionally, institutions like the University Library at the University of Illinois at Urbana Champaign started offering consultation services in 2011 to assist researchers in creating and reviewing DMPs for grant applications (Burnette, Williams and Imker, 2016). While existing resources often focus on ensuring DMPs meet funder requirements, it's important to recognise that compliance isn't the sole objective for reviewers (Miksa et al., 2023).

The study also found that DMPs are living documents needed before the beginning of the research project. Miksa et al. also noted this observation (Miksa et al., 2023). However, Mitcher (2015) found that a DMP is needed during and after the project. The study also found that many respondents were not utilising DMP template tools, although some reported using either DMP word or DMPonline template tools. DMPonline template tools, particularly the open-DMP template, were popular among respondents. The same finding was also observed by Miksa et al. (2023). Open-DMP was among the DMP online template tools selected to meet funders' requirements. Various studies have introduced innovative DMPonline tools like PARTHENOS DMP, Data Stewardship Wizard (DSW), and TUB-DMP,

each tailored to specific research domains and based on Findability, Accessibility, Interoperability, and Reusability (FAIR) principles for data management (Giorgio and Ronzino, 2018; Kamocki, Mapelli and Choukri, 2018; Pergl, 2019). Stodden et al. (2014) utilised control vocabulary and semantic descriptors to develop a DMP using ezDMP as a tool. Their workflow integrated ezdDMP to facilitate communication between researchers and funders, engage DMP stakeholders on artifact availability, and explain the artifact, creation, archiving, and reuse (Stodden, Leisch and Peng, 2014). Additionally, a web tool, TUB-DMP, inspired by Horizon 2020, aimed to maximize research data reuse (Kamocki, Mapelli and Choukri, 2018; Kuberek, 2018). These tools contain funder guidelines and domain-specific templates (Donnelly, Jones, and Pattenden-Fail, 2010; Reilly and Dryden, 2013).

The study underscored that a complete DMP should incorporate a type of data that should be collected and stressed the significance of a clear, specific, and detailed DMP. Mitcher (2015) emphasised that a complete DMP should incorporate the entire data life cycle, from discovery and collection to organisation (e.g., spreadsheets, databases), quality assurance/quality control, documentation (e.g., data types and laboratory methods), data usage, preservation, and data sharing (e.g., data policies and dissemination strategies). The benefits of DMPs for meeting funders' requirements of developing DMPs highlighted in this study include documenting key research activities. Kvale and Pharo (2021) emphasised how DMPs aid in formalising procedures, standardising methods, enhancing reproducibility and facilitating data sharing. Challenges identified included a lack of competency and awareness and the absence of DMP policies and guidelines. Despite the increasing prevalence of DMPs, many researchers still struggle to transition from planning to implementation (Burnette, Williams and Imker, 2016). Designated reviewers typically review the DMPs, but institutions like universities also offer DMP review services by research support staff before submission to funders (Miksa et al., 2023). Given the diverse practices in DMPs across disciplines, reviewers may face challenges in being experts in all aspects, such as metadata standards, repositories, and licensing. Consequently, the feedback quality on DMPs relies heavily on the reviewer's expertise and may sometimes lack the necessary depth and objectivity (Miksa et al., 2023).

CONCLUSION

The study highlighted the benefits of HLI researchers in developing DMPs to meet funders' requirements. Since most funders mandate a DMP, HLIs should train their researchers on how to create and utilize DMPs when applying for research funding worldwide. DMPs are essential for effectively managing and organizing research data throughout a project's lifecycle. While both word-based and online DMP template tools were discussed, respondents preferred online templates. These tools are user-friendly and widely accessible through various HLIs' websites, allowing researchers to customize them according to funders' specifications. Access to DMP template tools can significantly aid researchers in crafting comprehensive and tailored DMPs without starting from scratch. Typically, researchers should create DMPs at the beginning of a project, as this helps them plan and structure their data management processes from the outset. Furthermore, DMPs should be maintained and updated throughout the research project. Despite the benefits of DMPs in meeting funders' requirements, researchers in HLIs encounter challenges such as a lack of awareness about DMP requirements, insufficient training in developing and using DMPs for funding applications, and limited institutional support for data stewardship initiatives.

DATA AVAILABILITY

https://data.mendeley.com/datasets/5vvb44n57g/1

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AUTHOR CONTRIBUTION

The author conceptualized the study, designed it, and wrote the manuscript

AUTHOR CONTRIBUTION

The author declares that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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