

Data Management Plans: A Review

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ABSTRACT

With increasing world-wide emphasis on providing access to research data, data management plans (DMPs) have emerged as the expected way for researchers to formalise and communicate their intentions to stakeholders, including to their funders. This review paper focuses on a thematic analysis and presentation of empirical research on DMPs, a literature that is surprisingly limited, likely due to the young age of the field. Research shows that, despite the benefits associated with data sharing, DMPs have potential that is not being realised to the fullest. Researchers in scholarly communication and information science primarily have evaluated DMPs using text analysis methodologies, often supplementing them with surveys or interviews. Future study, especially in areas of machine-actionable DMPs is promising; such research is needed to further explore how DMPs can best be utilised to support data sharing.

Keywords : Data management plans (DMPs); Research data management; Data stewardship; Scholarly communication; DART framework; Review (Methodology).

1. INTRODUCTION

As funders and others have pushed researchers to make their data open and shareable, the importance of the data management plan has increased. Not all research will generate data,¹ but if a project does, how can researchers understand the scope of the task before them if they are not required to think ahead, and to plan how they will make their data available to others? Numerous articles have been written on the importance of making research data openly available, for example, with authors finding that open data supports reproducibility,² accuracy (potentially),³ and overall the quality and validity of the scholarly endeavor.⁴ Data sharing, however, presents a host of challenges.⁵ The importance of sharing data is not limited solely to the research ecosystem, rather, it spans into the open data efforts taking place among government agencies.⁶⁻⁷ It also reflects a long tradition of government agencies in the United States and Europe, including recent initiatives by funding agencies, that support data sharing⁸. Although the need for adopting a methodology that relies on data has been questioned in some academic disciplines,⁹ for researchers who will produce data as part of their research, an understanding of the way to manage that data throughout the research lifecycle is essential¹⁰.

Information professionals, especially those supporting the sciences¹¹ including medical science¹² and engineering, have led the way in supporting research data management (RDM), writ large. They have done this through both working with faculty individually and through the creation of systems to

house researchers' data (such as institutional repositories). The field of RDM, however, is young and for a number of years as it has grown, work on data management plans (DMPs) seems to have been carried out primarily at the local level; anecdotally, knowledge of how best to support scholars and their DMPs is shared within networks of scholarly communication librarians, for example, at conferences or via webinars, or is written up in professional journals (accordingly, we are not seeing DMPs discussed extensively in the research literature). This review assesses the current state of the field as it pertains to DMPs. In focusing on empirical research, and in grouping the research logically for presentation,¹³⁻¹⁴ this review seeks to provide a thematic overview of the research on DMPs by presenting selected articles for analysis, with an emphasis on scholarly sources."

2. DATA MANAGEMENT PLANS

Data management plans are considered the most effective way of asking the researcher to communicate his or her intentions for storing, using, maintaining, and making available the data resulting from a project. *Data management plans* are generally defined as documents that provide researchers with a mechanism for stating how they will manage data associated with a research project's data lifecycle¹⁵. Miksa et al. use the shorthand of describing them as "awareness tools."¹⁶ Plans can include aspects relating to "preservation, documentation, and sharing of data, samples, physical collections, curriculum materials and other related research and education products"¹⁷ and are meant to support sharing. They are distinct from data management planning which is less based on a formal

document and more of a process or workflow for managing active research data.

How researchers will save, store, and share their data cannot be an afterthought⁸. From the smallest to the largest research projects where data is gathered or created, no matter the field of study, consideration must be given to the data as a principal element of the research initiative. Researchers in all domains, therefore, who employ any number of research methodologies and who gather and collect all kinds of data, potentially storing the data in any number of formats, will need to plan ahead. Data management plans (DMPs) have a goal of formally “describing the data resulting from a project, and how they will be made publicly accessible for reuse.”^{11p.54]} Researchers might not create a DMP, however, if they are not required to do so; as late as 2015 some researchers were unaware of DMPs, making training on DMPs a necessity¹⁸.

At present, much research into DMPs in the United States is the direct results of the requirements put forth by United States federal funders such as the National Science Foundation (NSF) which began requiring DMPs as part of the grant proposal process in 2011. Other funders, both governmental and private, in the United States 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.

In countries such as the United States, institutional review boards or other ethics boards will approve research involving human subjects before researchers are authorised to carry it out. For the research to be approved, a data management plan or data security plan demonstrates how human subjects data will be maintained and secured, used by both researchers and those of the research team, and potentially how it will be shared.

After it is created, data must in many instances be shared. Institutional policies may require data be available¹⁹. Journals may also require data be shared that support the research articles they publish^a. None of this can happen without having first planned ahead, with data management plans as a key part in planning, budgeting, staffing, and developing habits that will enable data to be shared at a future point in time.

3. RESEARCH LITERATURE ON DMPS

The majority of research initiatives evaluating DMPs focus on the text of the DMPs themselves, as the analysis below will show. Methodologies generally include content analysis of the text of the DMP, often scoring it on a rubric. The textual analysis is often supplemented by either interviews of or surveys of researchers who have been successful in being awarded grants through the NSF or other funding agencies. Typical projects are those of Berman and Bishoff and Johnston: Berman looks at successful grants from the University of Vermont written between 2011 to 2014, analysing the text of the DMPs and interviewing researchers in an attempt to understand faculty

behavior concerning data management²⁰ and Bishoff and Johnston analyse NSF DMPs from the University of Minnesota for the period from 2011 to 2014, specifically seeking to understand more about data sharing²¹. These and other projects will be explored thematically in more depth below. We also note that venues for publication of empirical research on DMPs is somewhat limited, with a large number of the articles cited in this review having been published in a single journal, the open access *Journal of eScience Librarianship*.

3.1 Open Access to Data

How and when do researchers plan to share their data according to the research analysed? In considering the question of *how*, Bishoff and Johnston find that the majority of the DMPs propose “sharing or disseminating the results of the research project through publication in peer-reviewed journals and conference presentation.”^{21p.12]} Mischo, Schlemach, and O’Donnell also found 44 per cent of the DMPs they reviewed stated researchers would share their data via publications.²² We note that such proposals, however, cannot be considered “data sharing” as not all journals require that data be made available, and even if the journal does, some authors flout the requirement.³ Further, Van Loon, Akers, Hudson, and Sarkozy posit that when researchers indicate they will share data via publications, they do not mean as supplemental material.²³ Rather, when using this language, researchers consider the publication of the journal article as the mechanism by which the data will be shared, a situation that is not optimal given that data published in an article is generally not computational or reusable.

The *when* of data sharing seems to squarely be envisioned taking place at the end of the project, and not throughout. According to Bishoff and Johnston’s analysis, data sharing is most often slated to take place *after* publication²¹. While some funders find this an acceptable time period within to share data, others require data sharing at the date of project end. In interviews with PIs, Berman finds that negative stories of data impropriety, along with anguish about version control and preparation of files, makes sharing more appealing to authors later in the process²⁰.

3.2 DMPs Are Largely Ineffective

The literature surveyed in this review finds an overall ambivalence to DMPs on the part of researchers. Miksa, *et al.* categorise DMPs as “an annoying administrative exercise” that is ultimately not supportive of RDM¹⁶. Research that specifically analyses the DMPs or their use, once completed, tends to find them and the process used to create them, to be largely ineffective. How can this be? Mannheimer finds, in interviewing successful NSF grant recipients, that large-scale reuse of DMP verbiage was not an uncommon practice when submitting a grant, with little thought being given to it by researchers. Overall, the DMP was deemed a “supplementary document in the proposal”²⁴ and that “None of the PI interviewees used the DMP as a guiding document for data management in their lab.”^{24p.11]} This is similar to the findings of Parham *et al.*, who found that the majority of DMPs (56.3 %) failed to describe policies and provisions for data use and reuse

^a See for example, (ref. 4), Wiley’s survey of engineering journals.

Table 1. Summary of concerns about DMPs being ineffective

Concern Expressed in the Literature about the Ineffective Nature of DMPs	Author
DMPs: “an annoying administrative exercise”	Tomasz Miksa ¹⁶
PIs deemed the DPM a “supplementary document in the proposal”; “None of the PI interviewees used the DMP as a guiding document for data management in their lab.”	Sara Mannheimer ²⁴
The majority of DMPs (56.3%) failed to describe policies and provisions for data use and reuse and over 63% did not describe the policies or provisions for the redistribution of the data. Further qualitative analysis of DMPs indicated that researchers did not fully comprehend what is meant by the terms <i>reuse</i> and <i>redistribution</i> .	Susan Wells Parham ¹
Of the 834 DMPs reviewed, 88% exhibited little or no information about data details or presented a poor quality of description, half scored poorly on the attitude/effort criteria, and over 63% of data described in the DMP could not be found online. Causes for ineffectiveness: inconsistent requirements for data management plans by funding agencies, institutions, and publishers	Nicholas Smale ¹⁵
76% of a sample of 25 NSF DMPs had not shared their data as described in the original DMP	Steven Van Tuyl ²⁵

and over 63 per cent did not describe the policies or provisions for the redistribution of the data. Further qualitative analysis of DMPs indicated that researchers did not fully comprehend what is meant by the terms *reuse* and *redistribution*¹.

In a study of cohort of 8 Australian Universities published in 2018 that sought to evaluate the benefits of compliance, Smale et al. carried out an analysis of a sample 834 DMPs. The research team evaluated the DMPs based on three reported criteria: 1) detail and quality of information provided about physical and digital data storage; 2) attitude/effort towards DMP completion and writing quality; and, 3) data type clarity and findability. DMPs were then scored a 1 or 0 for each factor depending on whether the variables that fell within each criterion were exhibited. Results of this research show that for the majority of DMPs reviewed 88 per cent exhibited little or no information about data details or presented a poor quality of description, half of the analysed DMPs scored poorly on the attitude/effort criteria, and over 63 per cent of data described in the DMP could not be found online¹⁵.

Based on the results of this analysis, Smale et al. find that the majority of the DMPs assessed in this study would be “of little to no benefit to the researcher, institution or funding body, given that they do not appear to describe a plan for data management”¹⁵. Limited additional research has investigated the implementation of these DMPs to evaluate how successful researchers are in carrying out the tasks they have laid out. Van Tuyl and Whitmire reviewed twenty-five NSF DMPs to evaluate if the data sharing venue described in the DMP was in compliance. They found 76 per cent of these projects had not shared their data as described in the original DMP²⁵, results that are perhaps unsurprising given the low-quality of many DMPs. Researchers are revealed to be not as meticulous about implementing their DMPs as they are with other aspects of the funded initiatives^b.

^b This anecdotal observation is borne out by Bishoff and Johnston²¹, for example, who find that faculty have forgotten writing the plan in the first place, making it difficult to imagine the plan being implemented meticulously.

Given the poor quality and missing details for many DMPs, as well as the lack of follow-through in sharing data, as found in this study, Smale et al. assert that DMPs are in fact an ineffective mechanism to increase the data management skills of researchers or support the sharing of research data¹⁵. Perceptions of DMPs as ineffective might be surprising at first, especially given the importance of managing data in light of the overall research enterprise as described briefly in the introduction to this review. According to Mannheimer, researchers know that data sharing is mandated, but are too busy with their projects to implement it and other aspects of the DMP, a document that some admit they barely remember authoring.²⁴ The causes for this ineffectiveness, according to Smale et al., are the inconsistent requirements for data management plans by funding agencies, institutions, and publishers.¹⁵ While the term RDM is used ubiquitously in the scholarly communication ecosystem, the outcomes for each stakeholder are ill-defined which results in data management that lacks integration and ultimately fails. A summary of concerns about DMPs is provided in Table 1.

3.3 DMP Quality Does Not Impact Funding

In addition to DMPs being ill-designed and largely ineffective, studies have found little difference in the quality of funded and unfunded DMPs. An analysis of over 1200 data management plans by Mischo, Schlembach, and O’Donnell categorised the mechanism by which researchers stated they would share and store the data, which included 11 distinct locations, such as principal investigator (PI) websites, publication, disciplinary repository, and not specified to name a few. They then used this information to examine if there were any significant differences in proposed storage location and funded and unfunded proposals. Ultimately, they found, “there was no advantage – in terms of being funded – for proposals specifying disciplinary repositories or the institutional repositories as venues for data storage and access.”²⁶

Mannheimer, in her assessment of successful and unsuccessful DMPs at the University of Montana in the USA, finds that “the completeness of a DMP does not appear to

influence the success of a grant proposal²⁴[p.7]. Others note that funding can be cut for data management by the NSF in proposals, making it seem like it is not a true priority²⁷.

In interviews with successful NSF PIs, the sentiment emerges that the DMP need just appease the program officer at NSF²⁰⁻²⁴. Members of NSF review panels, when interviewed as parts of these research projects reviewed here, indicated that the quality of the DMP was not evaluated -- rather, its presence was noted; if present, it was generally deemed acceptable²⁰. This is despite the fact that the DMPs might not address all of the required elements, as Berman finds that 36 per cent of successful NSF DMPs did not address one major required element²⁰.

4. DART FRAMEWORK

To improve the quality of DMPs, the DART (Data Management Plans as a Research Tool) (<https://osf.io/qh6ad/>) project was put forth by information professionals in the United States and was funded by the Institute of Museum and Library Services (IMLS)²⁸. In this project, researchers analysed current DMPs with the goal of creating a sort of scoring rubric for plans in an effort to improve them. DART was not the first such instrument, however. Bishoff and Johnston mention a number of institution-specific checklists for use by PIs and information professionals developed prior to 2015, and they themselves created a checklist to evaluate a set of DMPs from their own institution²¹. In this same vein, in 2016 Wright enumerates and describes a number of tools to support DMP creation: Research data MANTRA from the University of Edinburgh, DMPTool hosted by the University of California Curation Center, and DMPonline based in the United Kingdom²⁹.

The DART framework was specifically based on NSF guidelines,³⁰ though it could be useful for any DMP given the homogeneous nature of the kinds of information they require.

As of 2019, the NSF DMPs allow for (but do not expressly require) the following information:

- The types of data, samples, physical collections, software, curriculum materials, and other materials to be produced in the course of the project
- The standards to be used for data and metadata format and content (where existing standards are absent or deemed inadequate, this should be documented along with any proposed solutions or remedies)
- Policies for access and sharing including provisions for appropriate protection of privacy, confidentiality, security, intellectual property, or other rights or requirements;
- Policies and provisions for re-use, re-distribution, and the production of derivatives
- Plans for archiving data, samples, and other research products, and for preservation of access to them¹⁷[p.11-25].

The DART rubric assessed criteria across three performance levels of complete/detailed, addressed issue but incomplete, and did not address. In addition to rating the DMPs based on the performance level across the performance criteria, the project team also recorded supplementary information about where researchers said they would share and archive their data, if a researcher mentioned an institutional repository

or other university resources, specific metadata standards, and more for each DMP they reviewed.

4.1 The DART Framework in the LIS Literature

A number of presentations associated with the creation of the DART Framework and the dissemination of the results are available on the DART website; presumably, all of these are authored or co-authored by either the project's PI or co-PIs. In addition, references to three publications are provided on the website^c. Utilising the validated rubric, the project team conducted an analysis of 500 DMPs within five academic institutions, spread across seven NSF directorates. Results of this analysis found that only 7.5 per cent of the DMPs failed to specify how the data would be shared, with sharing through journals to be the most prevalent overall.

DART has been used in the literature beyond the studies carried out by the DART grantees to a limited extent. Sara Mannheimer's funded initiative to investigate DMPs in successful and unsuccessful NSF proposals used the DART Framework for its analysis²⁴. Yet, extensive testing, validation, and reuse of the DART tool is limited to a small group of library practitioners, and has not seen widespread adoption among researchers as an analysis tool. Indeed, a cursory search of Library Literature and Information Science Full Text in August, 2019 yields zero results for a search for "DART Framework" and for "DART NOT darts." The dearth of research on this large, funded initiative is nonetheless disappointing, and potentially suggests that additional work is needed.

4.2 Funders of Research into DMPs

Research on DMPs is of interest to funders, as well as to information professionals. As mentioned, the DART project was funded by the IMLS, and other research, such as the analysis undertaken by Sara Mannheimer that was funded by the National Library of Medicine, National Institutes of Health²⁴. The overarching project was designed to assess the "impact of DMPs on grant-funded projects"²⁴[p.21]. If there is little research into DMPs, stakeholders such as funders should consider making this kind of research a priority in order to improve the use of, as well as the perception of, DMPs.

4.3 DMPs Going Forward

Recommendations in the literature for improving DMPs include making the documents themselves be machine-readable or machine-actionable to ensure their inclusion in existing workflows¹⁶. Machine actionability can be defined in this context as "the capacity of computational systems to find, access, interoperate, and reuse data with none or minimal human intervention."³¹ Under this model, DMPs could be quickly checked for compliance and provide useful links for finding related data and outcomes from research.

In particular, one of the principles supporting machine-actionability highlighted by Miksa, *et al.* includes the notion that DMPs are living documents that should be modifiable as

^c These publications are, per the website (<https://osf.io/uht5f/wiki/home/>). Please see the notes for publication.

a research project grows¹⁶. Much like a research approach may shift over the project timeline, the data that results from that research will potentially change as well. Thus, it is necessary to develop mechanisms that allow researchers to modify DMPs to reflect the actual data collected. It is plausible not only that metadata needs may change, but also locations for data sharing and archiving. Given the rapidly developing data repository ecosystem, a domain repository for sharing a certain type of data may not have been available at the time at which the research was funded, but over the course of a number of years, may have come into existence by the time the project concluded. The current inability to edit DMPs may be one reason why some of the early compliance research has shown DMPs to be ineffective.

There are a number of international efforts through the Research Data Alliance (RDA) to develop standards and best practices around machine-readable DMPs and exposing DMPs.

The DMP Common Standards working group³² is developing a common information model and specifying access mechanisms that make DMPs machine-actionable. While this group is still wrapping up, it has developed a minimal set of terms that would ensure interoperability of data management plan systems³³. These properties include, contact, cost, created, staffing, persistent identifiers, dataset-level metadata, licensing, and more. Another international initiative, the Go FAIR project supports the FAIR Principles, those that highlight the use of computers to support 1) Findable, 2) Accessible, 3) Interoperable, and 4) Reusable data³⁴.

5. CONCLUSIONS

This review demonstrates that, despite the essential nature of data to the research enterprise and the pivotal role DMPs play in supporting researchers in their activities, there is only limited scholarly activity addressing this emerging area. Many of the results indicate an overall indifferent (if not negative) response to the DMP requirement by both scholars and funders. While funders are well meaning in their efforts to support good science, the lack of clear requirements and assessment criteria for good data management have made DMPs ineffective.

The bulk of research projects to date have investigated the DMPs at a single institution (e.g., Northwestern University, USA¹⁸, University of Minnesota, USA²¹, the University of Montana, USA²⁴, although some have looked at multiple institutions (e.g. in the United States¹ and in Australia¹⁵).

DMPs are an essential tool for scholars and researchers as they carry out their research -- they help protect human subjects when done correctly, they support accurate storage and use, and they enable sharing. The DART Framework, in analysing DMPs, developed a rubric for evaluating DMPs going forward. A potentially useful tool for both researchers and the information professionals who support them, the DART rubric, however, is understudied at present. In fact, our overall understanding of the mechanics of DMPs is arguably less developed than our understanding of their need. This review finds that much remains to be studied, and finds DMPs a rich and worthy area of research going forward.

NOTES

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