International Perspectives and Challenges of Research Data Management Services in Academic Libraries

Research data management (RDM) refers to the process of creating and preserving data acquired during the research process, and organizing it in a systematic way for future retrieval and use. Cox and Verbaan (2018) identify six main components of RDM: creating, finding, organizing, storing, sharing, and preserving. Many argue that due to the information management skills academic librarians already possess, libraries within higher education institutions are best equipped for implementing RDM services (Koltay, 2022). Thus, academic libraries and higher education institutions who have begun to understand the importance of RDM have developed and curated services to aid researchers in navigating this new landscape, commonly referred to as either research data management services (RDMS) or research data services (RDS). While each library and institution has different issues to contend with, trends exist within the implementation of these programs that highlight specific areas that RDMS must deliver on to be successful and the challenges these institutions face.

Problem Statement and Research Questions

Our research seeks to understand where RDMS is currently at on the global stage.

> *RQ1:* What areas do international institutions recognize need to be addressed for successful RDMS implementation?
> *RQ2*: Of those areas, which contain considerable challenges?

By fully understanding the areas of implementation and the challenges that institutions face, we found commonalities between these issues to provide a framework of understanding. This framework consists of human, structural and technological components affecting RDMS implementation; libraries and research institutions must be aware of and address issues that arise in these areas paying particular attention to supporting skill acquisition and building comprehensive organizational structures to support research needs. By utilizing this framework academic librarians can plan for RDMS implementation in their own institutions by anticipating challenges they might encounter in the developmental stages, or to help find solutions for programming issues that already exist. In doing so, it is the hope that RDMS knowledge strengthens and can continue to be shared as more countries embrace it.

Background

Origins of trends in library and information science (LIS) research are not always easy to map due to the pace at which informational needs and behaviors change,

especially at different levels of institutions and across geographic boundaries. This makes it difficult to pinpoint the exact birth of RDMS as a mindset and as a practice. The Association of College and Research Libraries (ACRL) identified data-related issues as a top trend in U.S. academic libraries in 2014, specifically focusing on "open data, data-plan management, and big data" (Hamad et al., 2019, p. 77). These are ideas that are closely related to RDMS, but where did the concept known as RDMS begin and what prompted LIS researchers to develop the concept as we understand it today?

According to Latham (2017), funding was a large driving factor behind the RDMS movement. Large governmental and national institutions across the globe became financially invested in ensuring organizations upheld good data management practices. Specifically in the United States, these were the National Science Foundation (NSF), National Endowment for the Humanities (NEH), and National Institutes of Health (NIH). Following their fellow North American counterparts, institutes such as the Canadian Institutes of Health Research, the National Sciences and Engineering Research Council, and the Social Sciences and Humanities Research Council in Canada have also invested a considerable amount of time and resources in the study of RDMS (Tenopir et al, 2014).

In 2003, NIH mandated formal requirements for how research data was to be shared and maintained for researchers who were seeking funding for their projects in the sum of $500,000 or more (National Institutes of Health, n.d.). Though this mandate did not directly reference RDMS, it is clear that much of what concerned the NIH then falls within this field, specifically regarding their interest in the global collection and maintenance of research data. This interest has driven the need for ongoing RDMS research in the United States today. A cursory search on the Library and Information Science Source (LISS) database hosted by EBSCO of the term "research data management" returns articles about the topic that date back to 2007. Given that the NIH mandate was only four years prior to this, it follows that US-based researchers would begin to start asking themselves the questions about how the data would be managed and by whom.

Simultaneously, the UK-based Digital Curation Centre (DCC) set out to answer this same question when it hosted a round-table planning meeting for what would eventually become known as their Research Data Management Forum (Digital Curation Centre, n.d.), which they continued to host as recently as July 2021. While we may not be able to pin down a specific moment in time that led to the birth and creation of RDMS, we can surmise based on these shifts in cultural and institutional expectations around research data that the need for RDMS occurred within the last 20 years, with the most recent and intensive research beginning to escalate over the last decade (Latham, 2017).

Open Science

Prior to the invention of the internet, research data was not as easily accessible for researchers as it is today. The concept of trying to collect and organize large sets of data from researchers around the world would have seemed an almost impossible task. However, Pryor et al. (2013) suggests that a cultural shift in the information age in the 1990s followed by the invention of the world wide web led to the explosion of publicly accessible data, thus creating for the first time a real possibility of data management on a grand scale. One can argue that such an instrumental change in the way people perceived and handled data led to the need for better data management, which ultimately gave rise to the need for research data management specifically. However, it was not just the mere existence of a multitude of data sets in the hands of the public that created this need, or rather, this need did not merely arise from a desire for governmental regulation and control, but also because of a belief in a concept known as open science.

Open science is a "paradigm … based on data that researchers create, gather and use in large volumes and the opportunities that these resources have created for the advancement of science and technology" (Open Research Data Task Force, 2018). Simply put, open science is the idea that researchers publicly share data to encourage international collaboration that would benefit the scientific community by making the data more easily accessible. In theory, open science would reduce barriers to information access and also significantly cut back funding issues for institutions that lacked the financial means or national support to pursue desired research. RDMS "advanc[es] the notion of open science … [because it] promotes reproducibility by facilitating verified findings" (Singh et al., 2022, p. 11). Compiling and sharing data in open access databases would strengthen future scientific endeavors by providing greater data sets to pull from. It would also reduce the risk of repeating research and wasting precious limited resources.

Research Strategy

In analyzing the literature surrounding RDMS, we sought to gain better insight into the current standing of RDMS in the field and find common challenges that librarians face during implementation of services. A comprehensive literature review (CLR) as laid out by Onwuegbuzie and Frels (2016) was chosen for this task. The goal of this CLR is to summarize and categorize the current literature surrounding RDMS challenges faced by academic libraries and their respective research communities through an international lens.

Taking inspiration from Frich, Biskjaer, and Dalsgaard (2018), a clear process for gathering, sampling, and reviewing relevant sources was conducted . Five relevant databases were searched: LISS, Library and Information Science Collection, Academic Search Complete, Gale OneFile Information Science, and Science Direct. Search term combinations were created to suit each databases'

vocabularies, including: data curation, data analysis, data analy*, academic libraries, big data, academic librar*, RDM, RDS, services, lit review, research data services, and research data management. All searches were limited to articles published between 2012 and 2023.

To ensure all relevant materials were considered and collected for the CLR, all search results went through an initial title and abstract review. Inclusion and exclusion criteria were developed and subsequently followed by both team members. Articles were included for further review if they were in English, published between 2012-2023, mentioned services related to RDM, and had a distinct focus on academic libraries and researchers. Common terms that were sought to indicate correct selection included the above search terms plus: academic libraries, librarians, HEI (i.e., higher education institutions), and universities. Sources were excluded if they were not in English, preceded the chosen year range, or were solely focused on the technical how-to's of using related applications or technology tools for RDM, rather than implementation of services.

According to Onwuegbuzie and Frels (2016), this type of review encourages the use of multiple "MODES: Media, Observation(s), Documents, Expert(s) in the field, and Secondary data," (p. 39) thus stretching beyond the use of just academic articles. This includes things like blogs, webinars, videos, gray literature and more. To include these types of sources we looked for organizations interested in RDM issues through a Google search, then proceeded to search their websites for relevant resources. Keeping in mind the predetermined criteria, this process seemed to be less systematic due to the nature of finding these resources. Included resources needed to indicate an overarching theme of RDMS implementation within the first paragraph of written literature or the first five minutes of a recording.

Snowball searching (looking at papers that were cited in other works) was also utilized. This added a few more sources that seemed particularly relevant as they were cited in multiple previously found resources and therefore deemed important or relevant to the topic in question. Once resources were gathered and weeded, we had over 30 resources. These were fully reviewed with notes taken about challenges or issues that were seen during RDMS implementation mentioned in their findings sections. During the note-taking process, sources were loosely grouped into categories based on identified challenges. These categories changed as more sources were added to better reflect the types of trends that were identified.

Before continuing on to the findings, it is important to contextualize our epistemology. In this vein, our understanding of this topic is coming from a constructivist and critical theory lens. It is assumed that knowledge is created

within a contextualized space. Cultural, historical, and social realities impact how data are collected as well as viewed (Onwuegbuzie & Frels, 2016). Our interpretations come from a place of privilege, as we are both American, middle-class, and have an education that is centered around Western ideas and theories. Despite this, we try to respect and represent the multiple realities that are reflected in the literature in as unbiased a manner as possible. Additionally, we recognize that the use of the terms "economically developing" and "economically developed" countries (or emerging) are rife with potentially problematic connotations. In order to remain consistent with the research found on this topic which utilizes such terms, we have chosen to use these terms in our own research. It is not our argument, nor should it be conferred as such, that we view any of these countries as greater or less than another in any aspect other than in RDMS.

Findings

Current International Development of RDMS

The conversation around RDM is still considered to be "young" even though this has been an emerging issue for the last 20 years (Donner, 2022; Latham, 2017; Verbaan & Cox, 2014). Australia, Canada, Germany, Ireland, the Netherlands, New Zealand and the UK all have a head start on RDMS implementation, with a specific emphasis on advocacy and policy development (Cox et al., 2017). While it would seem that they are at a much more advanced stage, even they are encountering obstacles to fully develop rich programs (Perrier, Blondal, & MacDonald, 2018; Tenopir et al., 2014; Yu, H.H., 2017). However, issues deploying RDMS do not seem to be limited to these countries. Research that deals with economically emerging countries are focused on how to implement services while dealing with challenges that are compounded by their social and economic situations (Amanullah & Abrizah, 2023; Chiware, 2020; Singh et al., 2022). Because RDMS is such a relatively new phenomenon, and each country has its own set of cultural expectations and unique challenges in implementation, much of the literature is still laying the foundational groundwork for what RDMS is and how it can be most effectively used. Therefore, RDMS is very much still in its infancy and can be expected to shift and grow both in meaning and substance as libraries and researchers understand how it can be used. Given that the articles this paper reviews deal with studies conducted across 14 different geographical regions, and the content of these articles discuss how institutions in these regions are dealing with RDMS, it is clear that development is taking place across the globe.

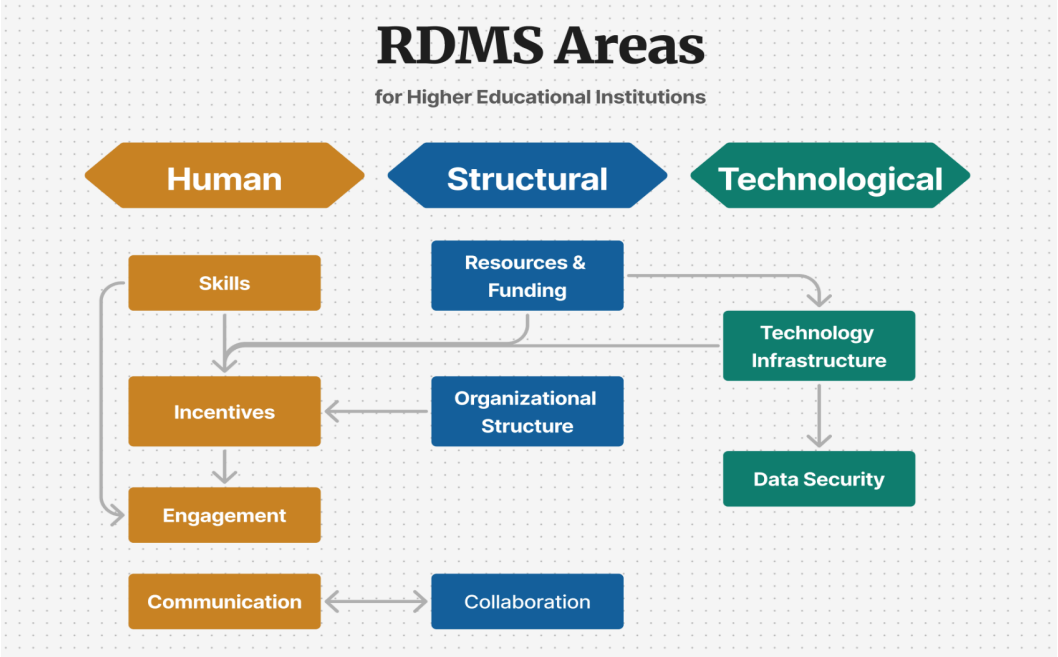
Areas of RDMS

During an analysis of the literature, categories of common challenges experienced

by academic librarians and researchers became apparent as important issues to address in RDMS research. These categories were created, reconsidered, condensed, and evaluated multiple times to ensure that they covered the complete story of RDMS implementation in global academic and higher education institutions. Eventually three overarching themes centering human, technological, and structural components were determined, with nine sub-categories fitting under these larger themes. These sub-categories included areas dealing with: skills, incentives, engagement, communication, data security, technology infrastructure and use, organizational structure, resources and funding, and collaboration.

Figure 1

RDMS Area Categories



In total roughly 29 articles were analyzed and cataloged into these areas. Several books, gray literature, and a few recordings were used to enhance our understanding of these areas. However, to keep the integrity of this process these alternative sources were not used during codification to standardize the inputs. This allows for comparable arguments across sources. These sources primarily came from researchers at academic institutions or professional organizations. Literature that is reviewed for the findings section comes from institutions outside of the US. The sources included in this review focus on 13 countries and two broader geographical regions. Both economically emerging and economically developed countries are represented in the literature for a fully comprehensive look at challenges that are affecting these institutions despite the level of current RDMS employment or development. Not all countries are currently represented in the literature reviewed for this paper, due to either limitations of access, language,

or topic infancy. Table 1 shows the breakdown of sources into corresponding categories.

Table 1

RDMS Challenges Breakdown

			Human				Technological		Structural		
Author(s)	Year	Country	Skills	Engagement	Communication	Incentives	Data Security	Tech Infrastructure	Organizational Structure	Resources/Fund	Collaboration
Al-Jaradat	2021	Jordan	x	x	x		x	x	x	x	x
Amanullah & Abrizah	2023	Malaysia	x	x					x		
Andrikopoulou, Rowley, & Walton	2022	UK	x		x				x		x
Bhoi, Patel, & Dutta	2023	India	x	x	x				x	x	x
Burland & Grout	2017	UK						x			
Chen & Wu	2017	China					x	x			
Chiware	2020	South Africa Africa				x	x	x	x	x	
Chiware & Becker	2018	South Africa	x		x	x	x	x	x	x	x
Cox & Verbaan	2016	UK		x							
Donner	2022	Germany	x	x	x			x	x		x
Fry & Ripp	2017	Canada	x					x			
Hamad, Al-Fadel, & Al-Soub	2021	Jordan	x	x	x				x	x	x
Harrison	2018	UK		x	x			x		x	x
Koltay	2019	Hungary	x	x	x	x	x	x	x	x	x
Latham	2017	UK & US	x		x					x	
Marlina & Purwandari	2019	Indonesia	x			x	x	x	x		
Masinde, Chen, Wambiri, & Mumo	2021	Kenya	x			x	x	x	x	x	x
Oo, Chew, Wong, Gladding, & Stenstrom	2021	Australia	x	x							x
Payal, Awashti, & Tripathi	2019	India	x			x		x	x	x	x
Perrier, Blondal, & MacDonald	2018	Canada	x		x			x	x	x	
Raju, Raju, & Johnson	2016	South African countries	x	x						x	
Sheikh, Malik, & Adnan	2023	nonspecific	x	x	x	x	x	x	x	x	x
Shelly & Jackson	2018	Australia	x	x				x	x	x	x
Singh, Bharti & Madalli	2022	India	x			x		x	x	x	
Tayler & Jafary	2021	Canada	x		x	x					x
Verbaan & Cox	2014	U.K.	x				x		x	x	x
Wong & Chan	2021	China	x	x					x		
Yoon & Kim	2020	USA South Korea		x		x					
Yu, Deuble, & Morgan	2017	Australia	x	x	x	x	x	x	x	x	x
			23	15	13	11	10	17	19	17	16

Human Interaction

Human interaction components are broken down into four subcategories: skills, incentives, engagement, and communication. Skills refer to a person's knowledge and ability to engage with the systems in question. Librarians need to possess the relevant skills RDMS requires in order to better assist researchers who are utilizing it. Researchers need the relevant skills to both create and understand the data they are compiling, submitting, or reviewing to successfully engage with RDM.

Incentives refer to the mechanisms that encourage use of RDMS for either the institution, its staff, and/or the researchers for whom the services are being offered, and the direct benefits received from doing so. If the individuals or institutions offering and/or using these services are not properly incentivized, the services will remain unused, thereby wasting limited time and resources. Similarly, engagement refers to the actual level at which researchers and library staff are using these services. While lack of engagement can be directly impacted by the lack of incentivization, it is not a one-to-one correlation, as there are other factors that can impact engagement levels, such as personal beliefs. Although they appear to be similar concepts, the research identifies incentives and engagement as two separate and independent ideas worthy of exploration, and therefore we have decided to list them as separate challenges.

Lastly, communication refers to the conversations about these services, or the lack thereof. Many researchers may not utilize RDMS because they are not aware of its existence within their own institutions. Communication also refers to the policies surrounding RDMS within an institution that librarians and other library staff may or may not refer to when implementing these services. As we will see, there is some interplay amongst all of these components. However, the literature indicates that these are challenges with enough nuance as to be discussed on their own as well.

Skills

Skills are defined as the knowledge and abilities librarians and researchers need in order to effectively interact with RDMS. Literature that mentioned skill gaps and training insufficiencies agree that this area is one of the most, if not the most, significant challenge to overcome for RDMS implementation. Twenty-three of the 29 articles referenced skill gaps as a significant area for improvement. Insufficient skills should be remedied by further training, however, budgetary constraints and limited resources often hinder this step. While skill gaps are pervasive, low confidence contributes to challenges in this area. Raju et al. (2016) also found that confidence plays a large role in librarians' abilities "to provide … assistance and guidance proficiently to researchers" (p. 174). Additionally confidence impacts

communication, another significant challenge to RDMS implementation. Even countries like the United Kingdom, which are considered leaders in RDMS, face challenges regarding skill gaps. Institutions are citing a lack of “professional development opportunities” (Latham, 2017, p. 264) as a reason for poorer competencies.

Incentives

Incentives for engaging with RDMS can be external or internal and affect individuals or institutions. External incentives include institutional or government policies, funding, or publication requirements, while internal incentives emerge from personal beliefs, such as wanting to contribute to open science or Findability, Accessibility, Interoperability, and Reuse (FAIR) principles. In both cases, prior experience with these ideas and requirements shape researchers' inclination to practice RDM.

Yoon and Kim (2020) explore the link between data sharing and data reuse among biology scientists and suggest that prior experience with data reuse increases the likelihood that researchers would participate in sharing their own data, while researchers inexperienced with data reuse hold doubts about how others might find their data sets to be useful. Similarly, South African researchers are less likely to engage in RDM practices when they are not properly incentivized (Chiware, 2020); this may be due to a lack of a national open science framework in African countries. For Jordanian researchers, the reward is in the publishing of data, not the management, which discourages them from continual engagement with the system (Hamad et al., 2019). Researchers do not feel properly motivated to use these systems because they either do not see what use others could find in their research data sets, or there is a lack of support for open science services (Yoon & Kim, 2020; Chiware, 2020; Hamad et al., 2019).

For academic librarians, lack of incentivization is often tied up with organizational issues. When librarians lack the proper support or skills, they are less likely to engage with a system they do not understand, a problem that is a much more prevalent issue in emerging countries that do not have a pre-existing understanding or belief in data sharing (Sheikh et al., 2023). Additionally the lack of internal incentives to implement RDMS stems largely from the fact that librarians are often missing key skills to do so effectively. As mentioned previously, a significant amount of the research showed that skills and training-related issues were the number one obstacle towards successful RDMS implementation. For institutions that seek to rectify this, providing their library staff with adequate training opportunities may be a way to combat these issues.

Engagement

Engagement refers to the level at which librarians and researchers are interacting

with RDMS. Incentives, structural environments, and personal beliefs and fears, come together as key factors that lead to either the action of engagement or disengagement.

Those who refuse to engage with or are simply unaware of the services offered can contribute to low levels of engagement. This can occur due to a reluctance to share data, borne out of an unwillingness to part with one's hard work. Researchers who do not understand or believe in the concept of open science are hard-pressed to relinquish their control over data. Librarians in institutions that do not have an open science framework in place typically have low levels of engagement because the organizational structure is not currently equipped to handle these services. This is a commonly encountered problem in countries that lack national support for open science initiatives (Chiware & Becker, 2018; Chiware, 2020; Sheikh et al., 2023). South African researchers request self-imposed "embargo periods" to wring as much information out of the data as possible before it goes public, "a rationale [that] negates the principle of sharing" (Raju et al., 2016, p. 173). Along those same lines, chemistry researchers at the University of Hong Kong were not aware of data management practices offered in their university, primarily due to the lack of institutional requirements and policies related to data sharing (Chen & Wu, 2017). Organizational structure issues that result in non-existent or underdeveloped policies contribute to the researchers' level of awareness, and thus engagement, with RDMS. These and other related issues are explored further in the section titled Organizational Structure below.

Lack of engagement by researchers can be a critical setback to successful RDMS implementation. Many institutions may not see the benefit to implementing an RDMS plan or policy if there is no willingness on the researchers' part to utilize it.

Communication

Communication refers to how information is conveyed to individuals. This includes one-on-one and one-to-many interactions. Miscommunication or lack of communication can have a negative impact on any type of provided services. If patrons do not know where to get help, what types of services are offered, or what their institutions expect of them, confusion is inevitable. Hamad, Al-Fadel, and Al-Soub (2019) note that there is a distinct lack of communication between the research community and the library itself that contributes significantly to the challenge of successful RDMS implementation. One of the leading voices in the European Research Libraries community, the Association of European Research Libraries (LIBER), highlights the importance of communication when engaging researchers (2022). Using institution-wide policies provides clear goals and expectations; they suggest policies that speak to open science values to reinforce RDMS use. Following up with in-person connections help individuals reinforce

these values while gaining the help they may need. This can be done at many different points during a researcher's career, from student to professional; the key is to establish personal connections.

Miscommunication does not just happen between the researcher and the library. In some cases, co-existing service providers such as library staff and IT professionals may deal with issues of miscommunication and misunderstanding because of a difference in their approach to RDM services (Latham, 2017). Due to the nascent nature of RDM, confusion around certain responsibilities and roles of who provides what services may arise. Additionally, as Latham (2017) suggests, IT professionals may not be concerned with the same thing library staff who are entrenched in American Library Association (ALA) tenets are, such as data privacy and security. A difference of culture can lead to a miscommunication or misunderstanding which may then affect the RDM services being provided or developed in these institutions.

Technology

The technology aspect of RDMS challenges consists of two subcategories: data security, and technology infrastructure and use. Data security refers to the protocols that institutions establish to ensure the protection of sensitive and important information. On an individual level, it can also refer to a personal feeling of security when entrusting institutions with important research data. Many researchers fear data misuse or copyright violations, which can be exacerbated if academic library staff and related stakeholders are not thoroughly vetting the security of the data they have been entrusted to protect.

Technology infrastructure and use refers to the specific systems in which institutions store the collected data and the ways they use these systems. Infrastructure concerns center around whether institutions are utilizing these systems effectively. Challenges arise when an institution lacks an understanding of what technology exists, how to use it, or how to begin the process of collecting research data in a way that academic librarians can successfully implement RDM services.

Data Security

Data security is as much about the physical measures institutions take to provide secure storage and appropriate access to materials as it is about researchers' understanding of how secure their data are. Data security is a big concern for researchers who are already weary of an open science paradigm. While they may not see the benefits to sharing their data, they are less inclined to do so if they do not feel their data will be protected for both short-term and long-term access. Al-Jaradat (2021) found that data security and confidentiality were among the biggest concerns for researchers and academic librarians in Jordanian institutions.

Comparably, respondents in a survey conducted of Chinese chemistry researchers indicated that their primary concern with data storage was "about the loss of research data, indicating that researchers are more concerned about the integrity of the data" (Chen & Wu, 2017, p. 350) than they are about the methods available with which to store it . Lack of data security also has other unintended consequences. When research and academic libraries have underdeveloped infrastructures, the security of data often falls on the researcher, who may be ill-prepared and ill-equipped to secure data, especially in large quantities, leaving the data vulnerable and subject to loss (Marlina & Purwandari, 2019).

While researchers may be feeling insecure about their data, driving them away from RDM services that may be available to them, academic library staff, who protect the data, also consider data security to be a high-level concern. An interviewee in Verbaan and Cox's (2014) research identified that data security was a high priority because they did not want any information breaches that would potentially jeopardize their relationship with their clients. Lack of skills and insufficient knowledge of appropriate systems can lead to data security issues and weakened infrastructures, thus exacerbating this problem.

Technology Infrastructure & Use

Providing the correct technology for RDM allows researchers to manage active data, helps describe data before it is deposited, promotes data sharing and oversees long-term preservation (Cox & Verbaan, 2019). If there is no technology infrastructure to support research data management, implementation is nearly impossible. According to a survey of 10 Jordanian higher education institutions, not a single library in the study had a data repository registered on the Registry of Research Data Repositories, which is a significant challenge for librarians in Jordan to overcome (Al-Jaradat, 2021). According to Raju et al. (2016) the benefits of a repository are to increase data visibility and collaboration amongst researchers, which then leads to an "increase[d] capacity to solicit funding" (p. 168). While some libraries in the survey did have some form of data preservation services available, the libraries had not developed or curated these services with RDM in mind, meaning they could not successfully meet the needs and nuances of RDMS. In the instances where these institutions did have some sample data on hand, it was very selective, retained only if it directly benefited the university, and the long-term storage and preservation of such data could not be guaranteed (Al-Jaradat, 2021).

Interestingly, although long-term data preservation and storage is most often commonly associated with RDMS, this only hints at the full range of data storage concerns (Verbaan & Cox, 2014). According to professionals who work with academic researchers, there is also a pressing need to handle the immediate "operational data," essentially the data that the researcher is using here and now in

order to get to the long-term data. This highlights the complexity of needs when it comes to these services, as it is not just something that occurs one time but is rather an ongoing process that requires continual commitment to the process.

Additionally, further challenges can arise when staff members who may not grasp the full scope of researcher needs, or are not invested in the same interest, are left to operate and maintain the infrastructure. Latham (2017) discusses this issue between library staff and IT professionals who support RDM services. Librarians become an active participant in the research process; they work closely with researchers and are better equipped to understand their needs on a research level. In many cases, library staff may not have the necessary skills to maintain upkeep on the infrastructure researchers are utilizing. Collaboration with IT professionals then becomes necessary. However, Latham (2017) found that these IT professionals tend to see themselves as removed from the process and have different ways of speaking about data needs. Ultimately, the difference in the way librarians view the infrastructure versus the IT personnel whose job it is to maintain it can lead to a clash of opinions that may create challenges for successful implementation. Collaboration as a challenge is discussed further below.

Structural Components

The Structural components of RDMS challenges are divided into three subcategories: organizational structure, resources and funding, and collaboration. Organizational structure includes policies, procedures, and institutional layout, while resources and funding deal with human, physical, and financial capital. Collaboration is concerned with how organizations and departments interact.

The first component, organizational structure, addresses an institution's lack of RDMS policies, the insufficiency of pre-existing policies, and the uncertainty regarding the role of the library in RDMS. The second structural component, resources and funding, concerns libraries and researchers typically seeing less involvement from governments and institutions in the form of monetary support. This situation leads to a lack of human resources (shortage of staff), lack of sufficient tools, and ultimately budgetary constraints that may inhibit successful RDMS implementation. Finally the third structural component, collaboration, plays a critical role in structural issues. Librarians are only able to do so much, and many lack the skills or knowledge to be able to independently meet the needs and requirements of every type of researcher or research they may encounter. Good RDM practices stress the importance of collaboration, both amongst internal and external stakeholders, including but not limited to institutional departments, IT staff, library staff, and the research community itself.

Organizational Structure

Donner (2022) contextualizes RDMS with a focus on an institution's culture and the overall organizational structure. She underscores how implementation will inevitably change how research is done through the institution. While a change in one person's workflow may be inconsequential as more individuals shift to undertake these practices, the institution will need to provide more support. Creating the correct support structure can foster new practices while cultivating an institutional awareness. Furthermore, Kleinveldt (2021) posits that researchers may experience data overload; this issue represents a structural design failure rather than a human weakness. This reinforces the need for support from the academic institution and calls for proper policies, guidelines, and services to support the researcher navigating these new practices.

At the same time, libraries struggle to find their place within the academic community where RDM practices are concerned. They strive to fulfill their roles and define the relationships necessary to provide the needed services (Perrier et al., 2018). Part of this is a lack of understanding (see Skills and Communication) but is potentially larger than an individual's limitation. Researchers also express doubt about the role the library plays in RDMS, which may stem from the communication challenges previously mentioned. Researchers may not know what skills librarians currently possess or what services they have readily available to them, and therefore do not see them as fit for RDMS implementation.

Another significant organizational issue is related to policies. In the libraries currently experiencing challenges with RDMS implementation, many have either severely undeveloped or nonexistent data management policies. According to a survey of librarians from academic libraries across multiple countries in Southern Africa, only 19% of respondents surveyed indicated that their institution currently had a policy in place, while 42% indicated that their institution had plans to implement a policy within one to three years (Chiware & Becker, 2018). Another 35% had no policies at all, while about 3% indicated that they were not aware if their institution had a policy or not. For these countries and the libraries that participated in the survey, organizational issues were the most prominent challenge they faced, with nonexistent policies coming in third. Organizational issues such as lack of RDMS policies or underdeveloped policies are a significant setback to successful RDMS implementation.

Resources & Funding

Resources and funding play a significant role in RDMS implementation, as it can determine how institutions provide services, if at all. Resources include both physical and human assets, and funding includes financial contributions from the government, institutions, or grants. In England, IT professionals and researchers

identified the cost of data storage as one of their biggest concerns; researchers want "cheap and easy access to data storage" (Verbaan & Cox, 2014, p. 215). In Jordan, funding issues are one of the most significant barriers that "hinders all the progress and growth of RDM in university libraries" (Al-Jaradat, 2021, p. 1). For South Africa, this challenge results in critical technology infrastructures remaining underdeveloped, causing researchers to deal with data security issues and possible data loss (Chiware, 2020). In academic libraries in India, librarians identify lack of funding from their "parent organization" as one of the most significant barriers to RDMS growth and implementation (Singh et al., 2022). These sources demonstrate a general lack of physical resources which further underscores funding gaps. Without the people or tools in place to support RDMS, and a lack of funding needed in order to facilitate these services between individuals and institutions, RDMS comes to a halt.

Collaboration

Collaboration requires communication and has a significant effect on all other areas. At an institutional level, this means different departments or, more broadly, different institutions working together. As mentioned earlier, RDMS relies heavily on IT support, while funding and policies will often involve administration or government. At minimum, this means that there are three separate departments working together to create and administer these programs. As Cox and Verbaan (2016) point out, there can be "a sense that research [does] not speak with a coherent voice in most faculties, each [research] department having a different viewpoint" (p. 322).

Although many recognize the potential of collaboration, opening lines of communication can be challenging. Raju et al. (2016) argue that collaboration enables departments to pool their separate knowledge and skills. Tayler and Jafary (2021) echo this sentiment and noted "expertise in data stewardship is unevenly distributed across higher educational institutions and is often isolated within disciplinary areas" (p. 80). Collaboration promotes a more equitable distribution of expertise, significantly improving current RDM services. Similarly, Chiware and Becker (2018) observed that institutions with greater success in RDMS implementation engaged in collaborative efforts ensuring all invested stakeholders played vital roles in service delivery, data management, preservation, and "enablement for its future use" (p. 14)

Considerable Challenges

The most significant challenge these institutions are facing is the lack of skills related to RDM and organizational structure. Skills as a considerable challenge stems from RDMS being a relatively new development in the LIS world. LIS academia needs to begin incorporating RDMS-based courses for future academic

librarians so that these skills are built into their general knowledge, rather than having to acquire them later on as they move through different stages of their career. As academia develops, so too will the understanding of RDMS on a broader scale. Toolkits can be created to provide currently existing institutions and libraries with the resources they need to teach their staff, researchers, and all invested stakeholders how to successfully implement and employ RDMS policies.

As far as organizational structure goes, it is clear that institutions need a more defined layout that ensures proper RDMS support across the board. A restructuring of current RDMS policies is needed for institutions where they already exist but are being underutilized. Finding out what funding is available, where funding is being focused, and opening doors to collaborative efforts to relieve librarians of the entire burden of implementation can be key strategies towards renewed RDMS efforts. It's clear that while these are individual areas that need to be addressed, all of these areas overlap in such a way that if one is lacking, the system as a whole will be affected. It is important that institutions attempting to provide RDMS consider all areas for successful programs.

Discussion

Academic libraries and higher education institutions have a long road ahead towards universal, standardized RDMS practices. Although a number of countries have already implemented strong RDMS programs, they face many of the same challenges as countries without similar programs. This suggests that the challenges being experienced by these institutions are not dependent solely on geographic location or depth of engagement in RDMS. The challenges are a symptom of a new, still-developing concept as a whole. However there are some region-specific barriers that hinder countries from successful implementation, such as a lack of national engagement in open science or open access paradigms

RDMS challenges are a shared struggle across borders. The most significant challenge for institutions is lack of RDM skills. Education is the way forward for better, more successful RDMS implementation. This needs to occur at the introductory level in LIS programs for future librarians, but also at the institutional level for librarians who are already engaged in systems that are developing or want to better develop RDM services for their patrons. With organizational structure issues being the second-most prevalent challenge across the board, this also highlights how these institutions should conduct a thorough investigation of their pre-existing systems in place to determine whether they are meeting the needs of their librarians and patrons alike. This analysis can be conducted through the use of surveys similar to those conducted in the articles referenced in this literature review, as well as through independent research on RDMS as a whole for in-depth understanding. The development or reevaluation of RDMS policies in these institutions is crucial.

It is clear that RDMS is here to stay, that academic institutions will need to provide these services, and that libraries will likely play a role in their implementation. Governments are more likely to provide federal funding to projects that use reproducible and accessible data sets. Following FAIR principles when it comes to data sets is one way of keeping up with these trends. Many institutions are choosing to incorporate these ideas into their RDMS as global awareness opens to the possibilities promised by open science initiatives.

Due to the fact that the US and other Western countries are still facing issues providing RDMS, expecting less economically developed countries to surpass even their level of services would be impractical (Tenopir et al., 2014; Raju et al., 2016). Raju et al. (2016) argue that the "complex issues relating to copyright, … ownership of data, lack of national legislation and the lack of national support for mandatory sharing of data that are generated through public funding" (p. 172) makes this task nearly insurmountable. While these institutions face larger hurdles, the challenges seem to be of similar origin, and therefore solutions found in other places may provide a road forward.

Conclusion

This comprehensive literature review sought to understand international implementation of RDMS: What areas are important for successful implementation and what are the considerable challenges within those areas? Throughout this paper, the research has highlighted the complexities of the challenges facing libraries providing RDMS in today's data dense world. It endeavored to synthesize relevant literature from authors across the globe to find common setbacks and possible solutions while keeping an open mind to not overlook disparate experiences. Overall RDMS is in a state of flux (Andrikopoulou et al., 2022), and while challenges may arise during implementation of these new services, the practices that accompany this data-driven change to research are becoming the norm.

The challenges found tell a story about confusion, mistrust, and structural insufficiencies. Disagreement exists about the role the library and library staff play in RDMS, though most of the research suggests that academic libraries are best equipped to handle this task. Additionally confusion can stem from a lack of communication between library staff and researchers which leads to a lack of engagement throughout the entire process. When governmental or institutional policies force researchers to engage with RDMS, mistrust in data security and infrastructure may prevent researchers from utilizing these services. Insufficiencies from library staff and researcher knowledge likewise contribute significantly to the challenges RDMS faces. Skill gaps were the biggest issue cited in the corresponding research and suggest that RDMS education, specifically in LIS academia, needs a robust reevaluation to better equip current

and future librarians with relevant skill sets. Collaboration amongst librarians and other interested stakeholders is one way to combat the current deficiencies in knowledge, as RDMS is a complex and multifaceted system that requires an all-hands-on-deck approach. While this research is specifically concerned with understanding the current challenges being faced during RDMS implementation, future research on overcoming these challenges would be highly beneficial. For countries with an invested interest in good research data management practices, exploration regarding how academic libraries and other institutions successfully implement RDMS would further inform best practices within this field.

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