A systematic literature review on research data management practices and services

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Abstract

Purpose – Research data management (RDM) has been called a "ground-breaking" area for research libraries and it is among the top future trends for academic libraries. Hence, this study aims to systematically review RDM practices and services primarily focusing on the challenges, services and skills along with motivational factors associated with it.

Design/methodology/approach – A systematic literature review method was used focusing on literature produced between 2016–2020 to understand the latest trends. An extensive research strategy was framed and 15,206 results appeared. Finally, 19 studies have fulfilled the criteria to be included in the study following preferred reporting items for systematic reviews and meta-analysis.

Findings – RDM is gradually gaining importance among researchers and academic libraries; however, it is still poorly practiced by researchers and academic libraries. Albeit, it is better observed in developed countries over developing countries, however, there are lots of challenges associated with RDM practices by researchers and services by libraries. These challenges demand certain sets of skills to be developed for better practices and services. An active collaboration is required among stakeholders and university services departments to figure out the challenges and issues.

Research limitations/implications – The implications of policy and practical point-of-view present how research data can be better managed in the future by researchers and library professionals. The expected/desired role of key stockholders in this regard is also highlighted.

Originality/value – RDM is an important and emerging area. Researchers and Library and Information Science professionals are not comprehensively managing research data as it involves complex cooperation among various stakeholders. A combination of measures is required to better manage research data that would ultimately move forward for open access publishing.

Keywords Research data management, Research data management practices, Research data services, Systematic literature review

Paper type Literature review

Introduction

From the start of the 21st century, academic libraries have been facing fundamental changes in library space, services and resources. This paradigm shift is primarily connected with evolving technological modalities, changing information needs and seeking behavior, multicultural community in higher education and evolving of services competitors of libraries. Currently, one of the most significant inceptions of services is research data management (RDM) (Pryor *et al.*, 2014). Some researchers (Hswe and Holt, 2011; Sanjeeva, 2018) called it a "ground-breaking"

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area for research libraries. Sanjeeva (2018) described RDM as a charming and evolving area for academic libraries; however, it is complex because of involving cooperation among various campus service departments to manage researcher's data for future use. Additionally, some called RDM as the extension of traditional services from advisory services/information literacy services to data literacy services, repository management, metadata tagging, collection management and data retrieval (Cox *et al.*, 2019). It has been observed that in the recent past, libraries are playing an "output" role in scholarly communication in the shape of providing scholarly material and support to researchers (Koltay, 2016), however, the emerging role is "inside out" because of RDM inceptions by academic libraries. RDM opens a "black box" of research for academic libraries (Cox and Tam, 2018). A recent study by Ashiq *et al.* (2020) points out that thought the research data have to gain importance since the past two decades; nevertheless, the library professionals are far behind to equip and enhance skills on RDM services especially in developing countries.

Many researchers have defined RDM as a process maintaining data produce during the research-life-cycle (Corrall, 2014; Cox and Tam, 2018). It involves all the activities including data planning, managing, processing, organizing, analyzing, preservation, access, reuse and creation of data. This emerging role of academic libraries is highly accepting by professionals to reinvent and realign the research support services. It is understandable that RDM services are going to produce a better image of the libraries, provide new learning horizons, enhance collaboration among various campus entities, build relationships with researchers and lead to evolving job descriptions (Faniel and Connaway, 2018).

The Research Planning and Review Committee of the Association of College and Research Libraries (ACRL) has recognized RDM as a top trend for academic libraries. ACRL puts emphasis on open data, big data and data management. Consequently, these data-related trends are now reinventing the services paradigm of academic and research libraries (ACRL, 2014). Similarly, the *IFLA Journal* has published two special issues (vol. 42, no. 4, December 2016 and vol. 43, no. 1, March 2017) highlighting different activities of RDM and RDM services being performed by the researchers and libraries respectively, as well as put some questions regarding current challenges, needed skills, provision of services and data literacy training. According to Cox and Tam (2018), libraries are providing RDM support and technical services to mitigate "data deluge," and support open access publishing and funder requirements. This ultimately requires the collaboration and technical support of other services departments within a campus. Hamad *et al.* (2019) indicated a high perception and awareness of libraries' roles and responsibilities relating to RDM and the challenges for academic libraries in Jordan to provide RDM services. Tenopir *et al.* (2014) conducted a survey to measure the attitudes and preparation of US and Canadian academic librarians toward RDM services including background, skills and education. They highlighted that librarians were considering RDM services as a part of regular library services and believed that such services will help in increasing the visibility of librarians in near future. Cox *et al.* (2019) examined the impact of research data services in academic libraries. Data were collected from 209 respondents in Australia, Canada, Germany, Ireland, The Netherland, New Zealand, the UK and the USA reporting RDM practices, challenges and activities. The results highlighted that libraries are providing advisory and consultancy services but not technical services. They indicated that "exogenous factors could lead to a major shift in the near future, with consequences for library services" (p. 1453).

There are few literature review studies on RDM, however, and those that exist have limited scope. Brochu and Burns (2019) conducted a literature review on the relationship of librarians and RDM. The study revealed that the material on this area overlaps with researcher support, research support services, open access and data repository

management. The material on RDM might distract from the basic learning and the role of librarians in a research group. Grant (2017) conducted a literature-based study on the relationship between research data and recordkeeping. The study revealed that there is no distinct understanding that record professionals are the most suitable persons to manage data. In addition, Grant (2017) presumed that research data sets might come under the jurisdiction of national and scientific archives. The study has certain limitations in that it has been extracted from the researcher doctoral work which untaken in 2014. Ng'eno and Mutula (2018) also conducted a literature-based study on RDM core issues in agricultural research institutes. Similarly, Fuhr (2019) investigated a literature reviewed study on the RDM skills gap in Canadian health sciences information workers. The study identified various skills that were required through the training of health professionals. The skills are knowledge of research methods, legal expertise, data curation, data analysis, visualization, grant hunting expertise, metadata knowledge, technical and soft skills.

The above-cited literature review studies indicate that there is no systematically organized research study covering all important aspects such as RDM practices, challenges, issues, librarian skills, library services and motivational factors behind RDM. Further, these studies have limited scope as one has outdated data (Grant, 2017), one focuses on RDM core issues (Ng'eno and Mutula, 2018) and one on gaps skills (Fuhr, 2019). Hence, this study aims to systematically review the literature on RDM practices, challenges, required librarian skills, library services and motivational factors. Additionally, this study will describe the methodological nature of selected studies to thoroughly understand the types of research are being conducted on this topic.

Research questions

There are four research questions:

RQ1. What RDM practices are being used by researchers to better manage research data?

RQ2. What are the key issues and challenges are being faced by researchers and research support staff?

RQ3. What are the needed skills and services are required for successful RDM implementation?

RQ4. What are the motivational factors for library support staff and researchers associated with RDM?

Methodology

This study applies the preferred reporting items for the systematic review and meta-analysis (PRISMA) guidelines (Moher *et al.*, 2009, 2015). According to Moher *et al.* (2009), the aim of PRISMA is to help the authors in reporting systematic literature review and meta-analysis. They further added that PRISMA is an evidence-based set of minimum items that are helpful for critical appraisal of published work. PRISMA is basically a hierarchical flowchart indicating the comprehensiveness of available literature of the target topic till the most suitable records are identified at the end. There are four main aspects of this model starting from identification, screening, eligibility and finally included records/studies. Initially, PRISMA was formalized for health care; however, it is equally applicable in other disciplines. Some recent studies in information management follow the PRISMA guidelines to systematically review the

published literature (Ali and Warraich, 2020; Mahmood, 2017; Rafique and Mahmood, 2018; Safdar *et al.*, 2020).

Search strategy

A broad search strategy was developed to extract the maximum relevant literature. The researcher selected the three subject-specific databases (LISTA, LISA and EBSCOHOST), summons discovery tool (Higher Education Commission Pakistan), Google Scholar and *IFLA Journal* because of their relevancy to the topic. The *IFLA Journal* was included as it has published two special issues on RDM. The following keywords were used to retrieve the data on February 17–19, 2020 at the Library of Higher Education Commission, Islamabad, Pakistan.

> "Research data management" OR "research data management practices" OR "research data management services" OR "research data management challenges" OR "research data management issues" OR "research data issues" OR "research data skills"

Inclusion and exclusion criteria

The inclusion criteria were:

- Studies that have been published between the years 2016 to 2020.
- Studies that are published in English language only.
- Document type include only research article (except when using Google Scholar as there is no such filter in Google Scholar).
- Studies that are covering more than one aspect of RDM. For example, studies that focus on RDM challenges and RDM practices or RDM skills or services or motivation factors.

The exclusion criteria were:

- Studies that cover a single aspect of RDM as only RDM practices or only challenges or only skills or only services.

Results

Overview of selected studies

A broad search strategy was made to extract maximum relevant data from four databases, one discovery tool and one core journal. A total of 15,206 studies were identified and their bibliographic information was imported into Endnote desktop. After removing duplicates and irrelevant records, the researcher initially found 118 potential records by reading titles and abstracts. The full text of the three articles was not found. Consequently, the remaining 115 full-text articles were downloaded. From these selected 115 articles, 19 studies fulfill the inclusion criteria (Figure 1). The overview of the included studies is presented in Table 1. The years of publication ranged between the years 2016 to 2019. There were four (n = 4) articles published in *IFLA Journal*. Most of the studies (n = 7) were published in 2019. The largest number of contributing authors (n = 8) were from the USA. The selected articles were published in 14 journals and these journals are published by 11 different publishers. The majority are commercial based publishers, few publishers belong with professional Library and Information Science (LIS) associations such as the American Library Association and Ontario Library Association, Canada (Table 1).

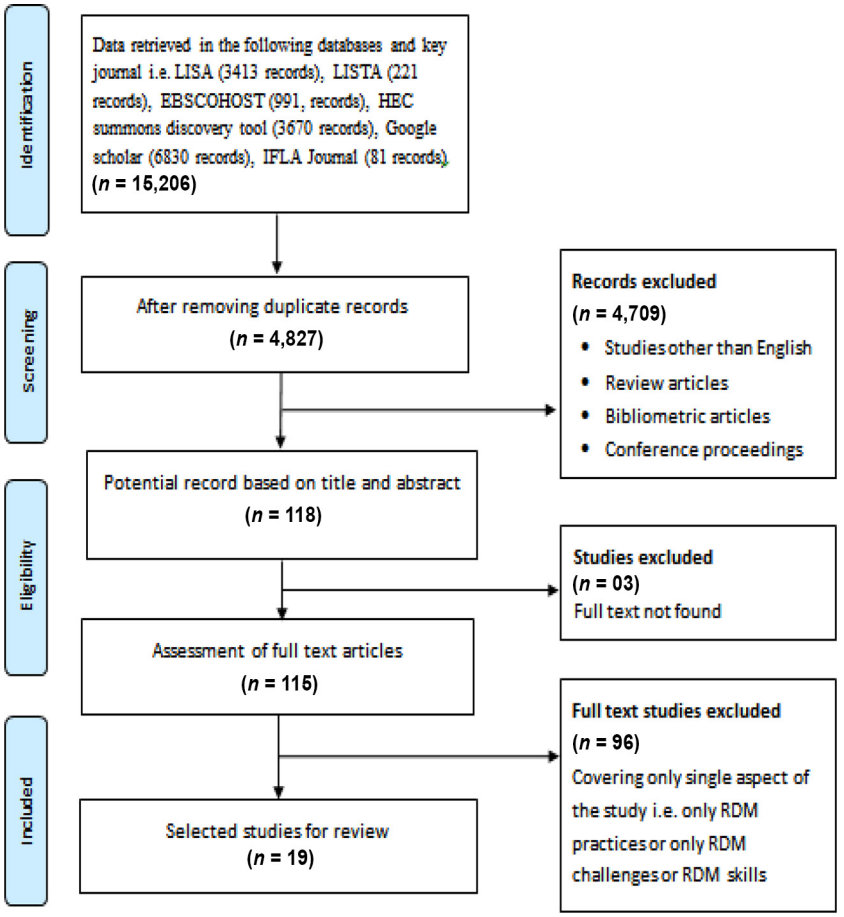

Figure 1.
Four-phase flow diagram of selection procedure of the studies

Methodological nature of selected studies

This study included the methodological nature of selected studies to thoroughly understand the types of research studies that have been performed on RDM, their methods, target population and sample size. The summary of the methodological nature of selected studies is presented in Table 2. It shows that 13 studies have a quantitative nature, five are qualitative and one study applied mixed methods research. All quantitative studies used a survey questionnaire as a data collection tool and four of these used a Web-based survey questionnaire. Three qualitative studies used a single method (i.e. interview, semi-structured interview and focus group interview), while the remaining two studies applied "interview and document analysis" and "interview and focus group discussion," respectively. The target population of these selected studies was researchers, faculty, librarians, information technology (IT) professionals and research support staff. Most of the studies (n = 12) collected data from researchers and faculty, the other four studies collected data from library professionals and the remaining three studies have a mixed target population including researchers, librarians and IT staff. The range of sample size in quantitative studies was

Table 1.
Overview/ bibliographic information of the studies

Sr. No.	Title	Authors/ Year	Country	Journal	Publisher
1	Research data management in Switzerland: National efforts to guarantee the sustainability of research outputs	Pierre-Yves Burgi *et al.* (2017)	Switzerland	*IFLA Journal (open access)*	SAGE
2	Managing research data at an academic library in a developing country	Renwick *et al.* (2017)	West Indies	*IFLA Journal (open access)*	SAGE
3	A brief assessment of researchers' perceptions towards research data in India	Tripathi *et al.* (2017)	India	*IFLA Journal (open access)*	SAGE
4	An Exploratory Sequential Mixed Methods Approach to Understanding Researchers' Data Management Practices at UVM: Integrated Findings to Develop Research Data Services	Berman (2017)	USA	*Journal of eScience Librarianship (open access)*	University of Massachusetts Medical School, USA
5	Analyzing the data management environment in a master's-level institutions	Stamatoplos *et al.* (2016)	USA	*The Journal of Academic Librarianship*	Elsevier
6	Awareness of Research Data Management Services at Academic Libraries in Jordan: Roles, Responsibilities and Challenges	Hamad *et al.* (2019)	Jordan	*New Review of Academic Librarianship (open access)*	Routledge: Taylor and Francis Group
7	Challenges and Practices of Research Data Management in Selected Iraq Universities	Mohammed and Ibrahim (2019)	Iraq	*DESIDOC Journal of Library and Information Technology (open access)*	Defense Research and Development Organization, India
8	Data management and sharing in neuroimaging: Practices and perceptions of MRI researchers	Borghi and Van Gulick (2018)	USA	*PLOS ONE (open access)*	Public Library of Science, California, USA (open access journal)
9	Developing research data management services and support for researchers: A mixed methods study	Perrier and Barnes (2018)	Canada	*Partnership: The Canadian Journal of Library and Information Practice and Research (open access)*	The Partnership/Ontario Library Association
10	Education Needs in Research Data Management for ScienceBased Disciplines: Self-Assessment Surveys of Graduate Students and Faculty at Two Public Universities	Pasek and Mayer (2019)	USA	*Issues in Science and Technology Librarianship (open access)*	ACRL (ALA)
11	Establishing a Research Data Management Service on a Health Sciences Campus	Vela and Shin (2019)	USA	*Journal of eScience Librarianship (open access)*	University of Massachusetts Medical School, USA

(*continued*)

Table 1.

Sr. No.	Title	Authors/ Year	Country	Journal	Publisher
12	Librarians' Perspectives on the Factors Influencing Research Data Management Programs	Faniel and Connaway (2018)	USA	*College and Research Libraries (open access)*	ACRL (ALA)
13	Maturing research data services and the transformation of academic libraries	Cox *et al.* (2019)	UK	*Journal of Documentation*	Emerald Publishing Limited
14	Providing Research Data Management (RDM) Services in Libraries: Preparedness, Roles, Challenges, and Training for RDM Practice	Tang and Hu (2019)	USA	*Data and Information Management (open access)*	Sciendo (De Gruyter)
15	Research data management and research data literacy in Slovenian science	Vilar and Zabukovec (2019)	Slovenia	*Journal of Documentation*	Emerald Publishing Limite
6	Research data management and sharing among researchers in Arab universities: An exploratory study	Elsayed and Saleh (2018)	Saudi Arabia/ Egypt	*IFLA Journal*	SAGE
17	Research Data Management Services in Southern Africa: A Readiness Survey of Academic and Research Libraries	Chiware and Becker (2018)	South Africa	*African Journal of Library, Archives and Information Science (open access)*	African Journal Online (AJOL) Non-profit company
18	Survey on the Needs for Chemistry Research Data Management and Sharing	Chen and Wu (2017)	China	*The Journal of Academic Librarianship*	Elsevier
19	User needs assessment for research data services in a research university	Joo and Peters (2019)	USA	*Journal of Librarianship and Information Science*	SAGE Publications

Table 2.
Methodological nature of selected studies

Sr. No.	Authors/ Year	Type of study	Method	Target population	Sample size
1	Burgi *et al.* (2017)	Qualitative	Interview + document analysis	Researchers	$n = 49$ Content analysis documents
2	Renwick *et al.* (2017)	Quantitative	Survey questionnaire	Researcher	$n = 65$
3	Tripathi *et al.* (2017)	Qualitative	Interview	Research students and faculty members	$n = 40$
4	Berman (2017)	Mixed method	Exploratory sequential mixed method	Faculty and researchers	$n = 6$ (interview) $n = 319$ questionnaire $n = 35$ DMPs
5	Stamatopols *et al.* (2016)	Qualitative	Semi-structured interviews	Faculty	$n = 36$
6	Hamad *et al.* (2019)	Quantitative	Survey questionnaire	Library staff	$n = 203$ (21 universities in Jordan)
7	Mohammed and Ibrahim (2019)	Quantitative	Survey questionnaire	Researchers, Librarians, IT professionals	$n = 155$
8	Borghi and Van Gulick (2018)	Quantitative	Survey questionnaire	Scientific researchers	$n = 144$ (participants from 11 countries and 69 institutions)
9	Perrier and Barnes (2018)	Qualitative	Focus group interviews	Researchers, IT professionals and Librarians	$n = 28$
10	Pasek and Mayer (2019)	Quantitative	Survey questionnaire	Graduate students and faculty members	$n = 210$ (131 graduate students and 79 faculty members)

(*continued*)

Table 2.

Sr. No.	Authors/ Year	Type of study	Method	Target population	Sample size
11	Vela and Shin (2019)	Quantitative	Survey questionnaire	Researchers and research support staff	$n = 52$
12	Faniel and Connaway (2018)	Qualitative	Interview and focus group	Academic library professionals	$n = 36$
13	Cox *et al.* (2019)	Quantitative	Survey questionnaire	Libraries research support staff	$n = 209$ (data from Australia, Canada, Germany, Ireland, The Netherlands, NZ, UK, USA)
14	Tang and Hu (2019)	Quantitative	Web-based survey	Researchers	$n = 241$ (respondents from five continents and 29 countries)
15	Vilar and Zabukovec (2019)	Quantitative	Web-based survey	Researchers	$n = 317$
16	Elsayed and Saleh (2018)	Quantitative	Web-based questionnaire	Researchers	$n = 337$ (respondents from Arab Countries including Saudi Arabia, Egypt, Jordan)
17	Chiware and Becker (2018)	Quantitative	Survey questionnaire	Library directors, library IT managers and library research support managers	$n = 30$ (20 fully and 10 partial responses)
18	Chen and Wu (2017)	Quantitative	Survey questionnaire	Researchers in chemistry subject	$n = 129$
19	Joo and Peters (2019)	Quantitative	Web-based survey	Researchers	$n = 186$

from a maximum of 337 to a minimum of 30 respondents. Similarly, the range in qualitative studies was from a maximum of 48 to a minimum of 28 respondents. The single study with a mixed-method approach conducted 6 interviews, 319 responses and content analysis of 35 data management plans (DMPs). This shows that most of the studies are quantitative nature and have targeted the researchers. There are only three studies that have respondents from multiple countries (serial no. 13, 14 and 16 in Table 2).

Characteristics of the studies

The extracted information from the selected studies is provided in Table 3. The first column provides author information, the second shows RDM practices used by researchers, the next indicates the challenges and issues surrounded with RDM, the fourth column specifies the needed services/required skills to better manage research data and the last column identifies the motivation factors for research support staff and researchers to deal with the research data.

Research data management practices

Across the 19 selected studies, the RDM practices are identified in 16 studies (Table 3). Most of the studies focused on RDM practices including data storage and data sharing practices (Elsayed and Saleh, 2018; Joo and Peters, 2019; Renwick *et al.*, 2017; Stamatopols *et al.*,2016; Tripathi *et al.*, 2017). Few studies comprehensively explore the RDM practices including data policies, size of the data, data organization, data processing, data storage, data sharing and data security (Vela and Shin, 2019; Vilar and Zabukovec, 2019). In addition, there are some studies that inform only the available services being offered by libraries including "guidance and consultancy services" and research support services (Chiware and Becker, 2018; Faniel and Connaway, 2018; Tang and Hu, 2019). It has been reported that there are still no RDM policies in institutions of developing countries (Mohammed and Ibrahim, 2019; Tripathi *et al.*, 2017); in contrast, Cox *et al.* (2019) highlighted that most of the institutions in developed countries have formal RDM policies. The extracted data described how in most of the cases, the researchers stored their data in personal management devices and external hard drives. There is only one study which indicates that DMPs are observed throughout in the lifecycle of a research project (Borghi and Van Gulick, 2018). Data sharing has been observed as being a complicating issue for researchers especially the sharing of raw data. While researchers share data through publications and presentations (Elsayed and Saleh, 2018; Stamatopols *et al.*, 2016), almost half of the respondents said they are not willing to share their research data (Joo and Peters, 2019), as raw data has been restricted and shared with a limited audience (Tripathi *et al.*, 2017; Vilar and Zabukovec, 2019). One of the main reasons they refrain from sharing raw data is that the data contains additional information that they will publish as findings in later stages of their research (Borghi and Van Gulick, 2018). Vela and Shin (2019) described that published data is shared through institutional and subject-specific repositories for the maximum benefits of the data.

The characteristics of RDM practices show that though RDM is maturing in developed countries and most of the institutions have RDM policies, it is in early stages and DMPs are not highly observed by researchers. The situation is far shakier in developing countries as most of the institutions have yet to devise RDM policies.

Research data management challenges

The challenges and issues are the most prevalent aspects in RDM as reported in all selected studies. The major challenges are data storage, copyright issues, limited organizational support, lacking skillful data staff, financial constraints, complex collaboration with various campus entities, data sharing concerns, data misinterpretation and data loss, respectively.

Table 3. Characteristics of extracted data of selected studies

Sr. No.	Authors	Practices	Challenges/issues	Need services/skills	Motivational factors
1	Burgi *et al.*		No formal DMPs Lack of utilization of standards Coordination issues Archiving issues Copyright challenges Costs of storage devices	Institutional RDM policies collaboration among stakeholders Online data storage repositories Research support services	
2	Renwick *et al.*	Data storage in personal devices Data back-up in hard drive and cloud storage	Assistant for proper archiving Copyright/permission issues Retrieval issues Safe storage Data backup	Proper data storage Establishment of data policies Data analysis skills Training and consultancy services	
3	Tripathi *et al.*	Non usage of metadata applications Data storage in personal management devices No general policies/guidelines Raw data is sharing with limited audience	Data organization, preservation and storage issues Data copyright issues Limited awareness about data–sharing policies	National level policy for RDM library support services Need of collaboration between library and researchers	
4	Berman	Metadata standards availability Data sharing through publications Long term preservation through external hard drives and personal devices Few submit data in repositories	Limited infrastructure Lack of university support Lack of library support Fear of misinterpretation of data Intellectual property concerns	Consultation and organizational support on (DMPs, copyright, privacy, metadata standards, best resources, policy framing and implementations, ethical standards) Technical support (data analysis, security, long term storage, institutional repositories, providing data set)	
5	Stamatoplos *et al.*	Misconception about RDM Data deleted once published Data storage in personal devices Data sharing through publications Raw data is available to limited audience	Data misinterpretations Copyright issues Lack of awareness about data/subject repositories Data ownership issues Lack of organizational support		

(*continued*)

Table 3.

Sr. No.	Authors	Practices	Challenges/issues	Need services/skills	Motivational factors
6	Hamad *et al.*		Financial issues Lack of research support librarians Staff misconception about RDM limited CPD opportunities Lack of collaboration Limited equipment's and infrastructures Researchers poor IL skills	Establishment of data repositories Tools and techniques to manage researchers data Need of skilled library staff Research consultancy services Technical supports for researchers	
7	Mohammed and Ibrahim	No RDM plan and policy No guidance on RDM Short term preservation of data Data storage in traditional sources such as documents, spreadsheets and graphs. Inactive data repositories	Lack of policy/guidelines Inadequate human and financial resources Insufficient infrastructure RDM misconception Limited institutional support	RDM policies and guidelines Training for the staff Collaborations within and outside universities/ organizations Subject-specific institutional repositories	
8	Borghi and Van Gulick	Funding opportunities for researchers DMPs are highly observed RDM training facilities Limited data sharing practices	Time as an constrain for data collection, analyzes and sharing Lack of incentives/benefits Limited training opportunities Financial costs Sensitive information in the data Format difficulties while data sharing		

(*continued*)

Sr. No.	Authors	Practices	Challenges/issues	Need services/skills	Motivational factors
9	Perrier and Barnes	Researchers manage and store data in various commercial products to non-proprietary databases Effective and easy to use data management tools such as Dropbox	Technological issues/ obsoleteness Cost of technological tools Data restrictions Data security and privacy issue Fear over data misuse	Institutional level data storage space Guidance on data security and data backup Clear policy/guidelines for DMPs	
10	Pasek and Mayer		Data processing and analyzing issues Data preservation issues Data curation and reuse Metadata description issues Database/data formats handling Discovery and acquisition of data	Data organization skills Data backup and storage availability Expertise in writing DMPs Research data sharing Long term data preservation Finding data set for reuse of data	
11	Vela and Shin	Availability of funding for researchers Limited information about DMPs Data organized in personal devices Data sharing through institutional/ subject-specific repositories Data preservation from 3 to 10 years	Inconsistency among project group members Insufficient digital space Data security Technological issues/ obsoleteness Lack of physical space		
12	Faniel and Connaway	Research data services through education, consultation and library outreached Supporting during writing DMPs Data curation service	Long time storage and preservation issues Shortage of experienced library staff Time-consuming activities	Library skillful human resources Cooperation among departments Need of technical resources Library leadership support	Better image Enjoying element learning new things Relationship building Evolving job description

(*continued*)

Table 3.

Table 3.

Sr. No.	Authors	Practices	Challenges/issues	Need services/skills	Motivational factors
13	Cox, *et al.* B16	Availability of formal RDM policy Collaboration among departments Primary leadership responsibility for planning about RDM	Lacking RDM skills Financial constraints Collaboration issues Staffing issues Infrastructural issues Understanding disciplinary differences Lack of mandate/rewards Legal issues Rapid technology change Preservation issues Library seniors support Compliance with funder requirements	Data curation skills Data description and documentation Legal, policy and advisory skills Understanding of research integrity Knowledge of the research lifecycle Subject/disciplinary knowledge	Funder compliance library relevancy and skillful role Needs of researchers Integrity Open science publishing Impact of research institutional policy
14	Tang and Hu	Data management planning services Data sharing and dissemination Data preservation Data discovery and access Metadata applications Data visualization Data organization and curation Having data repositories Availability of data processing software Data citation manager	Staffing issues Collaborative understanding Awareness issues Consistency of services as an issue Skill-set issue Infrastructural issues Funding/resources issues Lack of services usage Administration support challenges Librarians perception and attitude Discipline specific RDM services	Data documentation work metadata skills DMPs Collaborative work Data preservation Copyright management Data repository Data reproducibility Data file format understanding Awareness about tools/software/system/ infrastructure	

(*continued*)

Table 3.

Sr. No.	Authors	Practices	Challenges/issues	Need services/skills	Motivational factors
15	Vilar and Zabukovec	Data produced in spreadsheet, text and presentations Availability of data sources Data storage facilities Restricted access of data Proper citing of research data	Misuse of data Misinterpretation issues Legal and ethical concerns Lacking policies and right protection Fear of losing data Limited use of standard file-naming system	Formal DMPs Metadata practicing Standard file-naming Data set version control Data citation styles	
16	Elsayed and Saleh	Data generated in various formats Data preserved at least for six years None usage of metadata standard Data preservation is self-responsibility Data shared through publishing	Sharing data obstacles Privacy and confidentiality issues Time and efforts demand task Copy right issues Technical issues		Scientific progress Work visibility Open science support Avoid duplication Transparency of research Publisher requirements Getting grants Funding compliance
17	Chiware and Becker	Locating and using data sources Data analysis support Availability of data sets Copyright and patent advising Database design and management Data mining	Organizational structure issues Limited job descriptions No CPD opportunities Lack of well-defined policies Meager data storage facilities Financial issues Lack of IT infrastructure Lack of skilled staff RDM services misconception		Support open data Better use of data Advocacy Avoid duplication opportunities for better collaboration

(*continued*)

Table 3.

Sr. No.	Authors	Practices	Challenges/issues	Need services/skills	Motivational factors
18	Chen and Wu	Experimental and observational data Data recorded in various formats Data preservation through personal devices and subject data repository	Data storage problems Data misuse issues Security problems preservation problems Intellectual property concerns Data quality problems Data sharing issues Academic ethics issues	Need of data processing tools Metadata application Publishing data in data repository Data-files-naming systems Data backup tools Standards for collecting data Data policy of funding agencies	
19	Joo and Peters	Availability of RDM services Data format availability Data storage in personal, cloud and repositories Limited data sharing	Privacy issues Lack of expertise in data sharing Time and efforts to share data Intellectual property issues Lacking in data sharing tools Misinterpretation of data	Data analysis Data visualization help Assistance in finding repositories Assistance in DMPs Data collection help Data cleaning help Data documentation	

Note: CPD = continuous professional development; IL = information literacy

All these challenges are basically associated with limited funding, training and policy issues and require leadership, as well as donor's proactive role to better manage research data.

The major three challenges are data storage, copyright issues and non/limited organizational support (Berman, 2017; Burgi *et al.*, 2017; Chiware and Becker, 2018; Stamatopols *et al.*, 2016; Tang and Hu, 2019; Tripathi *et al.*, 2017). The limited number of staff and skill deficiencies was another big challenge for research support staff (Ashiq *et al.*, 2020; Borghi and Van Gulick, 2018; Cox *et al.*, 2019; Faniel and Connaway, 2018; Hamad *et al.*, 2019; Mohammed and Ibrahim, 2019). Financial constraints were another big challenge reported in the studies. Some linked financial were identified as challenges to managing rapid technological change and its effects on related software, hardware and other technology matters (Cox *et al.*, 2019; Perrier and Barnes, 2018; Vela and Shin, 2019), while, others see financial issues as an obstacle to devising RDM services (Hamad *et al.*, 2019; Chen and Wu, 2017). Lack of collaboration among library service departments including IT, research offices and between academic researchers was also observed (Cox *et al.*, 2019; Hamad *et al.*, 2019). Some studies reported data-sharing issues (Chen and Wu, 2017) and data sharing is challenging due to the limitation of data sharing tools (Joo and Peters, 2019). One reported that sharing data is perceived as a task demanding time and effort (Elsayed and Saleh, 2018). These major challenges and limited facilities ultimately resulted in researchers fearing data loss, misuse and misinterpretation (Berman, 2017; Joo and Peters, 2019; Perrier and Barnes, 2018; Stamatopols *et al.*, 2016; Vilar and Zabukovec, 2019).

Research data management needed skills and services

The needed RDM services, skills and responsibilities were reported in 14 studies. The need for an RDM policy is the initial, basic and most reported item (Ashiq *et al.*, 2020; Burgi *et al.*, 2017; Mohammed and Ibrahim, 2019; Renwick *et al.*, 2017). Tripathi *et al.* (2017) indicated the need for a national-level research data policy in India. The advanced countries highlighted the need for clear policy and guidelines specifically for DMPs (Perrier and Barnes, 2018). Some studies reported the need for proper storage facilities (Burgi *et al.*, 2017; Renwick *et al.*, 2017) and Perrier and Barnes (2018) precisely described the need for institution-level data storage space. Research support services were shown to require a major contribution from libraries and research offices to help in better manage research data. Such services are crucial and need to be offered as "consultancy and guidance services" to researchers throughout the life-cycle of their research project. Burgi *et al.* (2017) reported the need for consulting, training and teaching services for researchers. Similarly, Renwick *et al.* (2017) described researchers being trained to manage data. Berman (2017) reported comprehensive research support services including consultancy services and technical support. Research consultancy services were usually guidance in writing DMPs, intellectual property guidance, metadata standards, policy framing and implantation and application of ethical standards. Technical support included assistance in data analysis, security, long term storage, the establishment of institutional repositories and providing data sets. Most of the studies described and highlighted the need for technical support as data curation skills, data analysis and visualization, data description and documentation and subject or disciplinary knowledge (Cox *et al.*, 2019; Joo and Peters, 2019). All these services require skillful and highly professional research support staff (Faniel and Connaway, 2018; Hamad *et al.*, 2019), especially skills in writing data manage plans (Pasek and Mayer, 2019; Tang and Hu, 2019; Vilar and Zabukovec, 2019). The "collaboration" was another needed skill (Faniel and Connaway, 2018; Mohammed and Ibrahim, 2019; Tripathi *et al.*, 2017) among various campus services departments including libraries, IT departments, training department and research offices.

Motivational factors for libraries and researchers

The motivational factors for libraries and researchers to support RDM services have been reported in only four studies. There are various motivational factor identified in each study including support open data initiatives, donor compliance (Chiware and Becker, 2018; Cox *et al.*, 2019; Elsayed and Saleh, 2018), evolving image and skillful role of library/librarians (Cox *et al.*, 2019; Faniel and Connaway, 2018), avoiding duplication of effort (Chiware and Becker, 2018; Elsayed and Saleh, 2018). Faniel and Connaway (2018) reported other motivational factors were the enjoying element, new learning opportunities, relationship building and evolving job description. The motivational factors described by Elsayed and Saleh (2018) were increasing work visibility, transparency of research and confidence in research results while sharing data.

Overall, RDM has provided a platform to establish relationships with researchers, and support open access publishing which resulted in a better image of libraries and improved job descriptions of librarians.

Discussion

The study aimed to systematically review the literature on RDM practices, challenges, needed services/skills and motivational factors. The researchers selected 19 studies fulfilling the inclusion criteria of the study. The reviewed literature revealed that RDM is in an immature stage. Comparatively, RDM is better observed in developed countries than developing countries.

RDM practices identified in most of the studies were data storage, preservation and data sharing practices. There were only two studies that thoroughly investigate the RDM practices that include data policies, size of the data, data organization, data processing, data storage, data sharing and data security (Vela and Shin, 2019; Vilar and Zabukovec, 2019). Mostly RDM plans are not highly observed and the researchers stored data in personal management devices. Data sharing practices is also limited and most of the studies identified that researchers shared their data through publications; however, the raw data has been restricted and shared with a limited audience, group members and persons in close contact with the researchers (Joo and Peters, 2019; Stamatopols *et al.*, 2016; Tripathi *et al.*, 2017; Vilar and Zabukovec, 2019). Overall, RDM practices are not exemplary and are surrounded with certain challenges for researchers, as well as libraries and librarians

This study identified five major challenges and obstacles on the basis of the highest appearance in selected studies. The challenges were data storage issues, intellectual property concerns, limited organizational supports, insufficient and inexperienced research support staff and researchers' fear of loss and misinterpretation of data. Data storage and related issues are connected primarily with archiving problems, long term preservation challenges, data backup, the rising cost of storage devices, limited equipment, poor infrastructure and insufficient digital space. The intellectual property of the data remains a crucial concern among the participants especially when data was generated through the teamwork of a funded project (Stamatopols *et al.*, 2016). Although RDM has been called a "ground-breaking" area for research libraries (Hswe and Holt, 2011; Sanjeeva, 2018), limited organizational support has been found. Other notable challenges were technological issues especially related to software, hardware and rapid change in IT, as well as the rising cost of tools. It has been noted that most of the organizations are yet to devise RDM policies (Chiware and Becker, 2018; Mohammed and Ibrahim, 2019; Perrier and Barnes, 2018; Vilar and Zabukovec, 2019). The policy-making ratio is better in

developed countries as Cox *et al.* (2019) conducted studies in eight developed countries and described that most of their institutions have formal RDM policies.

The limited awareness among researchers is another challenge. Stamatopols *et al.* (2016) showed that there is confusion among researchers about research data and stated the researchers "perceived data [as that] which they consult during their projects instead of the data generated by them." Similarly, Tang and Hu (2019) highlighted that RDM services are being offered to researchers but are not properly used by researchers. This shows the lack of awareness among the researchers, as well as such services being of low priority for libraries and senior administration. Moreover, it is understandable that managing research data involves complex cooperation among various stakeholders including researchers, donors, research support staff, IT department, senior support, higher administration and higher education institutes. This complex cooperation is ultimately the cause of certain challenges for all stakeholders.

The five needed major skills/services identified on the basis of highest appearance in the selected studies were research data policy, research support services, technical support, data analysis support and establishment of data repositories, respectively. These five skills are fundamentally linked with the proactive role of research support staff and leadership. Faniel and Connaway (2018) described the need for library leadership support to develop better research support services and this ultimately would happened though skillful library human resources and coordination among various campus entities. Cox and Tam (2018) stated that RDM opens a "black box" of research for academic libraries which libraries can only open through collaboration with researchers, donors and coordination with other research support departments; more importantly, it requires a senior or higher authority support.

To support RDM is a big responsibility for organizations especially libraries and research support staff including the IT department, research office and librarians. Although professionals are looking to support RDM services (Cox *et al.*, 2019; Faniel and Connaway, 2018), however, their organizations are not looking to take the necessary initiative that helps RDM. The sluggishness that has been observed at the organizational level includes non-formal policies, lack of incentives or rewards, no professional development of the staff involved in RDM activities, lack of awareness among the community, infrastructural issues and inadequate higher administration support. All these challenges need to be addressed through mutual support of key stakeholders including donors, higher administrations, researchers, and more importantly, collaboration among research support staff. This is a way that we can open the "black-box" of research.

Limitation and future research direction

This is a systematic literature review and it is possible some relevant studies might have been missed. Further, the data were limited to published studies between the years 2016 and 2020 and further limited to specific databases and sources.

It has been found that only one study used a mixed-method approach to investigate the RDM initiatives, hence, more studies using the mixed-method approach and qualitative method approach may be needed to understand the RDM in depth. Moreover, future studies are needed that examine RDM as per the lifecycle of research that is data management planning, sources of data, the volume of data, data processing and analysis, data sharing, data storage and preservation, reuse of data, data rights and retrieval of data. The investigation of RDM services in connection with research libraries and other research support staff will also be worthwhile.

Implications of the study

Policy implications

Policymaking is one of the main observed areas that is done poorly especially in developing countries at institutional and country levels. The reason behind this a poor collaboration among higher education institutions and/or research boards, funding agencies and higher education commissions or ministries. These stakeholders should sit together and make compulsory while granting funding to researchers to submit their research data in their institutional or subject repositories and also publish their work in open access journals. The data ownership issues in this regard should also be resolved while working in a team and additionally prepare mechanisms such that later researchers should acknowledge and cite the work of earlier researchers.

Practical implications

Lack of RDM skills is a real concern for researchers and library professionals and this is the major reason behind poor management of research data. The higher education commissions or ministries, funding agencies and higher educational institutions and/or research boards should address this issue and allocate some budgets to the training of researchers and library professionals. In particular, the focus should be on DMPs, data processing and analysis, data description and data sharing tools and platforms. Additionally, as we are witnessing how the LIS profession is greatly changing, developing and evolving in this technological era, library professionals especially library leaders should come forward and make necessary arrangements to develop the skills of the professionals to better manage research data and offer research support services. Otherwise, it might be computer scientists and data experts who occupy this important area in the future.

Conclusion and recommendation

This study contributes to our comprehensive understanding of key aspects associated with RDM including practices, challenges, needed services/skills and motivational factors for researchers and LIS contexts. Most of the studies are quantitative nature and the participants were researchers and faculty. There are limited studies on LIS contexts (library directors/librarians, IT departments, research support staff) that also investigate RDM services. The study discovered that RDM is gradually gaining importance among researchers and academic libraries; however, it is still poorly practiced by researchers and academic libraries. Further, RDM is comparatively better observed in developed countries over developing countries. The developing countries are yet to devise national and institutional level research data policies and to establish institutional data repositories. Moreover, RDM is a complex process that involves various key stakeholders including researchers, faculty, donors, higher education institutions, libraries and various departments within the institutions that are involved in offering RDM services. A tripartite agreement is required between researchers, donors and higher education institutions to better manage research data and mitigate various challenges and duplication efforts. This agreement could further aid open access publishing in the future.

The study recommends that a tripartite agreement should be developed and policies devised to ensure that research data should be available openly through subject and data repositories, and researchers should publish their work in open access journals. The intellectual property issues should be resolved while allocating the project by donor agencies and higher education institutions. RDM plans should be thoroughly detailed and to this end, necessary training should be arranged. The donor agencies and higher education institutions should arrange training opportunities and incentives for the staff who are

actively involved in research support services especially consultancy in writing DMPs, data processing and analysis and data description guidance.

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