Received: 21 April 2024 | Revised: 29 May 2025 | Accepted: 7 July 2025

DOI: 10.1002/asi.70008

REVIEW ARTICLE

JASIST WILEY

Research data management services in academic libraries to support the research data life cycle: A systematic review

Richard Cheng Yong Ho | **Suei Nee Wong** | **Patsy Chia** | **Chris Tang** | **Magdeline Tao Tao Ng**

National University of Singapore (NUS) Libraries, Singapore, Singapore

Correspondence
Suei Nee Wong, National University of Singapore (NUS) Libraries, 12 Kent Ridge Crescent, Singapore 119275, Singapore.
Email: mlbwsn@nus.edu.sg

Abstract

Academic libraries play an increasingly crucial role in providing services, information, education, and infrastructure support related to research data management (RDM). This systematic review aims to provide a comprehensive and critical analysis of the state of RDM services offered by academic libraries worldwide. Utilizing the systematic review methodology, the paper examines 89 empirical studies to answer four research questions: (1) the types of RDM services implemented by academic libraries; (2) what are the infrastructure, workflow, and resources used to support these services; (3) what are the reasons for implementing these RDM services; and (4) the effectiveness of these RDM services in supporting the research data life cycle, if any. This review highlights the critical reasons academic libraries provide RDM services and how they implemented these services through partnerships, infrastructure, and systems, and adapting to new workflows within the library. These findings also examine the balance between institutional contexts, researchers' needs, and library resources required to provide these RDM services. By investigating these questions, the results will provide recommendations and guidance for academic libraries interested in implementing RDM services in their own library and institutional contexts.

1 | INTRODUCTION

Traditionally, academic libraries have been responsible for selecting, curating, and preserving library collections to enable access to scholarly records in diverse formats. They also provide support for discovering, accessing, and utilizing the content. Over time, the role of academic libraries has evolved and expanded to include a substantial provision of support for scholarly research endeavors, including research data services, scholarly communication, digital initiatives, and user experience (Ducas et al., 2020). A crucial aspect of this evolution is the increasing recognition of research data management (RDM) as a vital component of research support services. As highlighted in a report by the joint force on research data services formed by the Association of Research Libraries (ARL) and the Canadian Association of Research Libraries (CARL) in 2020 (Whitehead

Richard Cheng Yong Ho and Suei Nee Wong are co-first authors.

et al., 2021), the roles of research libraries regarding research data principles, policies, and approaches to managing research data can be strengthened. This includes implementing strategies for discipline-specific research data, identifying library processes for automation, developing economic models to scale and sustain shared resources, and prioritizing research data management and stewardship.

Another perspective is that "research data is fundamental to scholarly inquiry" (Bryant et al., 2017, p. 401). Given that data is an important research output, facilitating its discovery, retrieval and access can be seen as a core part of librarians' work (Surkis & Read, 2015). Gordon et al. (2015) shared a similar view, explaining that librarians have always been managing research outputs like books and journals and is therefore natural to extend their job scopes to include RDM. These studies highlight the evolving roles of academic librarians in RDM.

1.1 | RDM and the research data life cycle

Several papers in the literature (Amanullah & Abrizah, 2023; Andrikopoulou et al., 2022; Ashiq et al., 2021; Cox & Pinfield, 2014; Gordon et al., 2015; Pinfield et al., 2014; Shelly & Jackson, 2018; Tang & Hu, 2019) cited Whyte and Tedds (2011) for their definition of RDM which is "the organisation of data, from its entry to the research cycle through to the dissemination and archiving of valuable results." In other words, RDM encompasses the organization, storage, preservation, sharing, and reuse of data collected during research projects (Ashiq et al., 2022; Cox & Pinfield, 2014; Subaveerapandiyan & Ugwulebo, 2024; Tripathi et al., 2017).

To support RDM, academic libraries have attempted to provide RDM services across the entire research process. These range from basic services, such as extending traditional reference services to include consultations on data management plans or curating resource guides to help users locate datasets and repositories, to more advanced services like setting up an in-house data repository and providing other data-related technical support (Fearon et al., 2013; Sinha et al., 2023; Tenopir et al., 2012; Tenopir et al., 2017).

According to Cox and Tam (2018), librarians use life cycle models to help them identify the type of RDM services to provide and to explain these service offerings to their users. Since a research data life cycle model covers all stages of data handling from planning to preservation and reuse, it offers a simple and convenient way for libraries to visualize the research process. Ball (2012) describes how the United Kingdom Data Archive (UKDA) Lifecycle model and the Australian National Data Service (ANDS) Sharing Verbs enable academic libraries to integrate the RDM services into a scholar's workflow, while Verhaar et al. (2017) discuss how Leiden University developed a catalogue of data management services based on life cycle models developed by UKDA, ANDS, and the Digital Curation Centre (DCC). The DCC life cycle model, which focuses on data curation and preservation processes, was also adopted by some libraries, as noted by Masinde et al. (2021) and Mthembu and Mbatha (2022). Similarly, ETH Zurich relied on a research data life cycle to implement its RDM approach (Töwe & Barillari, 2020). Despite some weaknesses, Cox and Tam (2018) agree that using research data life cycle models enriches librarians' understanding of the research process. Brochu and Burns (2019) also highlighted the importance of librarians understanding the research data life cycle to effectively support RDM.

1.2 | The impact of open science on RDM practices

Given their role in the stewardship of scholarly and research records, academic libraries naturally take an interest in matters related to open research and scholarship (Whitehead et al., 2021). The literature discusses RDM, such as Bishop et al. (2021), Tenopir et al. (2014), and Wilms et al. (2020), emphasizing its critical role in the research process and highlighting that proper RDM was not just essential but also required by the researchers. The implementation of open science policies, such as Plan S by cOAlition S in Europe and the Nelson Memo in the United States, has further influenced RDM practices and services in academic libraries. These policies encourage the adoption of RDM as a foundational element of open science, ensuring that research data is accessible and reusable. The Organisation for Economic Co-operation and Development (OECD) also highlighted the importance of open science in addressing global challenges (OECD, 2015). The Association of College & Research Libraries (ACRL) also highlighted the growing trend of open science and reproducibility in academic research, indicating that libraries need to consider how they can expand their roles in RDM to advance open science (ACRL Research Planning and Review Committee, 2024).

1.3 | Upskilling librarians to support RDM

With such a context, it is clear that librarians need to be adequately trained so that they can understand and

empathize with researchers to offer effective RDM services that better address their needs. This observation is shared by Cox and Verbaan (2016). Moreover, consultation-based research data services, which align with traditional library reference services, were increasingly becoming part of librarians' job responsibilities (Tenopir et al., 2019). This growing emphasis on developing librarians' RDM capabilities is supported by numerous studies which further underscore the necessity of upskilling and training librarians. Academic librarians' capacity and readiness to provide a comprehensive range of research data services were discussed in papers such as Cox et al. (2017), Cox and Pinfield (2014), Cox and Verbaan (2016), Pinfield et al. (2014), Tenopir et al. (2017, 2019), and Verbaan and Cox (2014). While training librarians is important, it is critical to note that training alone is insufficient to enable librarians to successfully offer RDM services due to institutional context (Read et al., 2019). This is because RDM is essentially a multi-stakeholder process. Bryant et al. (2017) also noted that RDM requires the attention of the entire academic institution, rather than letting the responsibility fall on a particular unit within the institution.

1.4 | RDM as a multi-stakeholder process

Thus, it is important to recognize that RDM activities and services are not solely developed by academic libraries (Cox et al., 2017). Cox and Verbaan (2016) highlighted the dynamics between librarians, IT staff, and research administrators, emphasizing a transition from individual supporting roles to forming partnerships. This could be attributed to the complex nature of RDM (Cox & Pinfield, 2014; Morgan et al., 2017) which requires all these stakeholders within the institution to have a common understanding so that seamless and effective RDM services can be implemented. Collaborations with external stakeholders such as the ANDS in Australia and the National Institutes of Health (NIH) in the United States of America are also pertinent as highlighted in several papers like Cox et al. (2017), Gordon et al. (2015), Yu et al. (2017), and Shelly and Jackson (2018). Such collaborative partnerships are essential for delivering RDM services in many institutions. However, competition for jurisdiction in RDM within institutions does exist as illustrated by Cox et al. (2017), resulting in certain stakeholders not fully understanding the libraries' role in RDM. Therefore, libraries need to carefully manage their relationships with other units to provide effective RDM support (Cox & Pinfield, 2014). These are important factors that academic libraries need to consider when implementing new RDM services, balancing between the competencies and skills of library personnel against the resources and partnerships required.

1.5 | Our research questions

While a few systematic reviews have examined current RDM practices and services (Ashiq et al., 2022; Ashiq & Warraich, 2023; Donner, 2023; Safdar et al., 2023), they often focused on the motivations, challenges, and barriers librarians face when providing RDM services. Oo et al. (2022) conducted a systematic review focusing only on specific aspects of RDM practices or services, for example, on research data management training. Liu and Liu (2023) investigated how academic libraries were engaging in open science, which includes RDM.

Despite the valuable insights provided by these previous systematic reviews on such specific RDM areas, a more comprehensive view of RDM that examines the types of RDM services provided, reasons why these services were implemented, and how they were implemented effectively would be beneficial for academic libraries and other stakeholders. As seen in the literature review earlier, RDM is a multi-stakeholder process that also involves a variety of factors and thus it is crucial to learn about RDM services alongside the contexts, reasons, and factors involved during implementation by academic libraries.

Therefore, with RDM gaining prominence in the academic library landscape, this review aims to fill the gaps by offering an updated, comprehensive, holistic, and global perspective on how academic libraries are providing RDM services to support the research life cycle, including the reasons for implementing these services, the resources required to implement them, and the effectiveness of these services in the present literature. In doing so, this review will enable academic libraries to identify the types of RDM services adopted by peer institutions, along with the contextual factors and rationales underpinning these implementations. In addition, it facilitates an assessment of the resources and collaborative partnerships necessary for the successful implementation of such RDM services. By enabling academic libraries to critically evaluate their institutional frameworks, resource allocations, and existing gaps, they can then identify opportunities to adapt and effectively implement tailored RDM services within their respective institutions.

As such, these are the four focused research questions (RQ) guiding the review:

> **RQ1.** What are the RDM services provided by academic libraries?

TABLE 1 Inclusion and exclusion criteria using SPIDER.

SPIDER	Inclusion criteria	Exclusion criteria
Sample (S)	Studies that investigate university students, faculty staff and researchers, professional or admin staff, and other librarians	Nil
Phenomenon of interest (PI)	RDM services offered by academic libraries that have already been implemented and operationalized. Timeframe from 2010 to 2024	RDM services offered outside of academic libraries, such as public libraries or solely by other university departments. Studies that do not mention that the RDM services have already been implemented and operationalized in the university or library context, e.g., research pertaining to perceptions, future trends, goals or expectations, barriers and challenges faced, factors influencing RDM, or data management in a non-research context, etc.
Design (D)	Studies must report original research findings, be published in English language and in peer-reviewed sources	Articles that do not report any original research findings such as reviews, systematic reviews, or non-peer reviewed publications, e.g., posters, blogs, opinions, conference proceedings, comments, editorials, etc.
Research type (R)	Any studies utilizing qualitative, quantitative, or mixed-methods	

RQ2. What are the mentioned infrastructure, workflows, and resources used to support these RDM services?

RQ3. What are the reasons to implement these RDM services?

RQ4. Are these RDM services effective in supporting the research data life cycle?

2 | METHODS

2.1 | Inclusion and exclusion criteria

The SPIDER (Sample, Phenomenon of Interest, Design, Evaluation, Research type) framework (Cooke et al., 2012) was used to define the key criteria of the review. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) checklist (Page et al., 2021), as seen in Table S1, Supporting Information, was used for reporting.

To answer the RQs, this review included studies that explicitly mentioned the provision of RDM services by academic libraries supporting the research data life cycle. Academic libraries play an important role in supporting the intensity of research at their academic institutions. Services provided by resource or public libraries are excluded, as their mission and scope differ from academic libraries. Such libraries also tend to have specialized collections and implement services that serve a broader range or a unique set of users, which are different from those that academic libraries serve. Although the services can be targeted at university students, faculty staff, researchers, professional or admin staff, and other librarians, studies focusing on measuring RDM current knowledge, motivations, challenges, and barriers without detailing the specific types of RDM services provided by the library were excluded. Details of the inclusion and exclusion criteria are presented in Table 1.

2.2 | Information sources and search strategy

Comprehensive searches in the following bibliographic databases were performed on 2 May 2024: PubMed; Embase.com; Education Resources Information Centre (ERIC) via Proquest; Scopus; Library, Information Science and Technology Abstracts (LISTA) via EBSCO; and the Web of Science (WoS) Core Collection (Science Citation Index Expanded, Social Sciences Citation Index, Arts and Humanities Citation Index, Conference Proceedings Citation Index-Science, Conference Proceedings Citation Index-Social Sciences and Humanities, Emerging Sources Citation Index). There were no limits or restrictions applied to the search (e.g., date, language, study design) as these were already excluded based on the criteria listed in Table 1 after exporting the results into EndNote 21. The search strategy consists of a combination of subject headings and keywords search in title/abstract fields focused on the concepts of "data management" and "academic libraries" or related terms. The final search strategy was approved by co-authors and improved after initial feedback. Full details of the search strategies are presented in Table S2.

Additional searches were also carried out. This includes searching the references of the included studies to identify other potentially relevant studies. Relevant websites such as academic library consortium websites from the International Federation of Library Associations and Institutions (IFLA), the Association of Research Libraries (ARL), the Association of College & Research Libraries (ACRL), and the Association of European Research Libraries (LIBER) were also searched to identify library reports or other gray literature. This resulted in the inclusion of the ACRL white paper by Tenopir et al. (2012) into the review.

2.3 | Selection process

The initial set of records retrieved (4316) from the various bibliographic databases was imported into EndNote 21. After removing 1255 duplicates, 1561 records were also excluded in EndNote using the filter function based on exclusion criteria. These included non-English articles (88) and items that do not report any original research findings such as books (50), reviews or systematic reviews (144), and non-peer-reviewed publications (108), for example, posters, opinions, comments, editorials (77), and conference proceedings (576). An additional 518 records were removed based on the publication date range from 2010 to 2024. The final set of results (1500) was agreed by the reviewers and imported into Rayyan for screening.

Three review authors (RH, WSN, CT) independently screened (blinded) the titles/abstracts using Rayyan software, a screening tool to prioritize the screening process based on language, date of publication (from 2010 to 2024) and the appropriate study types to speed up the identification of relevant records for full text retrieval. Any discrepancies found were resolved through a consensus via discussion. The titles selected at the title/abstract level (166) were subsequently exported to Microsoft Excel 365 for full text retrieval.

Four review authors (RH, WSN, PC, CT) were involved in full text screening. The full texts retrieved (157) were checked against their eligibility criteria. Disagreements between reviewers during full text screening were reconciled via consensus or arbitration by the fifth author (NTTM). Eighty-nine eligible studies were included for critical appraisal and data coding/extraction.

A PRISMA flowchart was used to document each stage of the selection process (see Figure 1).

2.4 | Risk of bias assessment

The MMAT version 2018 (Hong et al., 2018) was used for quality assessment by four independent reviewers based on the quantitative, qualitative, and mixed-method studies on this topic. For the potential studies to be included in the quality assessment, studies must receive a rating of "yes" for the two main screening questions "Are there clear research questions?" and "Do the collected data allow to address the research questions?" Subsequently, studies are assessed based on the MMAT questions for each research method. All studies were included in the systematic review regardless of the assessment.

2.5 | Coding

The coding scheme for RQ1 and RQ3 were developed based on the RDM survey and Research Data Services identified in Cox et al. (2019). Cox et al. (2019) survey was also supported by Tenopir et al.'s, 2014 foundational RDM research which defined advisory RDM services as "informational, consulting-type services (e.g., helping faculty and students find a place to deposit their research data or pointing to data management plan examples)" and technical RDM services as "technical, hands-on services (e.g., running an institution housed data repository or helping researchers write data management plans)." Table 2 shows the coding scheme generated to identify RDM services for RQ1 alongside the Research Data Services found in Cox et al. (2019).

Similarly, the coding scheme for RQ3 utilized Cox et al. (2019) survey responses on the "major drivers of RDM services," which aligned well with our focus to answer RQ3. Table 3 shows the coding scheme generated for RQ3 against the list of major drivers for RDM services in Cox et al. (2019).

For RQ2, the team designed a categorical coding scheme based on three themes observed in the included studies which are (1) infrastructure, (2) resources, and (3) workflows, utilized by academic libraries to support RDM services. Infrastructure referred to any kind of IT systems, content management systems, software, spaces, or facilities used to support the RDM services. Resources referred to the personnel, budget, funding, and partnerships required to implement the RDM services. Workflows referred to the personnel's expanded roles or reassignment to RDM, or the creation of new teams to carry out the RDM services. Breaking down the codes into these three themes helped to quickly and broadly identify the resources, partnerships, or infrastructure required by each academic library to implement the RDM services at their institutions. Here is a list of the codes for RQ2:

- Infrastructure—Partners
- Infrastructure—Spaces & Facilities

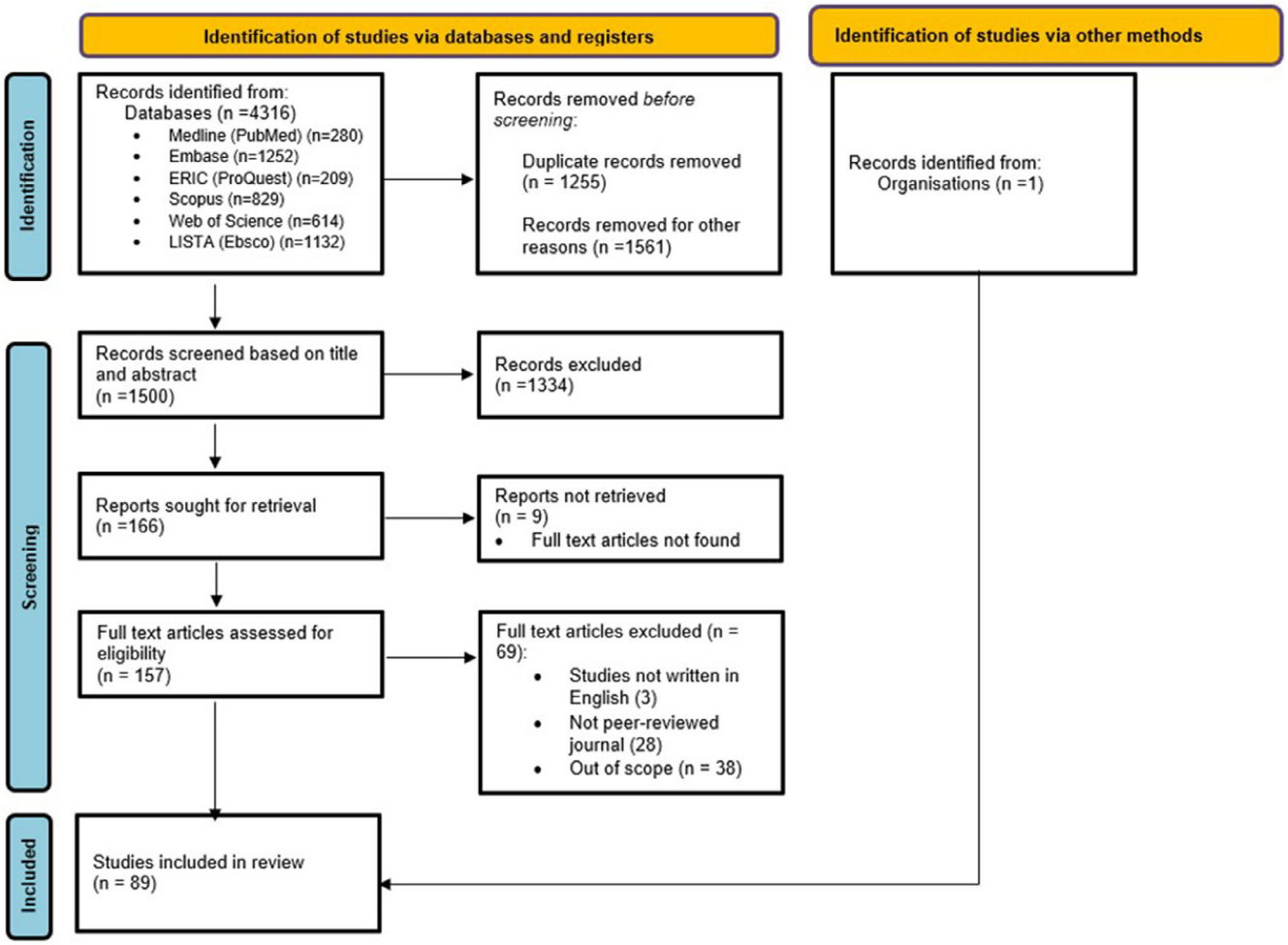

FIGURE 1 Flow diagram of the systematic review and inclusion of studies.

- Infrastructure—Systems
- Resources—External partners
- Resources—Internal partners
- Resources—Personnel
- Resources—Money & Budget
- Resources—Training & Learning
- Workflows—Revised Library Workflows

As for RQ4, free-text coding was employed. Any mentions relating to the effectiveness of services implemented or the measurement of the effectiveness of services implemented were extracted.

A standard data coding form was developed to pilot-test on full text. Two authors (RH, CT) independently coded three sample studies from Corrall et al. (2013), Federer (2013), and Tenopir et al. (2013) to test the codes. After the initial coding, four authors (CT, RH, WSN, PC) came together to discuss the discrepancies in coding structure. The team divided the 89 studies accordingly. The process continued over a period of 2 months as the coding team met multiple times to discuss, deliberate, refine, and clarify the coding scheme as necessary. The final authors (CT, RH, NTTM) then checked through all the coding done and resolved any conflicts to ensure consistency. All data were subsequently synthesized and tabulated into tables and charts using Microsoft Excel 365 for the reporting in this systematic review.

3 | RESULTS AND DISCUSSIONS

3.1 | Study selection

Following the methods described earlier, Figure 1 below shows the PRISMA flowchart of the studies that were identified, retrieved, screened, and included for this review.

3.2 | Study characteristics

A total of 89 studies were selected and coded for analysis. An overview of the included studies can be found

TABLE 2 Coding scheme for RQ1.

Coding scheme for RQ1	Types of research data services listed in table IX of Cox et al. (2019) study
Advisory—01 DMP	Data management planning (DMP) advisory service
Advisory—02 Training/ Education	Data management training and/or data literacy instruction
Advisory—03 Guides	Maintaining a web resource/guide of local advice and useful resources for RDM
Advisory—05 Data Use/Analysis	• Promote awareness of reusable data sources, such as data archives • Provide support for search and retrieval of external data sources • Offer an advisory service on data visualization • Offer an advisory service on data analysis • Offer an advisory service on data mining
Advisory—06 Active Storage	Offer data storage advisory services
Advisory—10 Publishing/ Sharing	• Offer advice on copyright and/or intellectual and/or licensing property rights relating to data and data management • Offer data citation advisory services • Offer data publication advisory services
Advisory—11 Curation/ Preservation	• Provide advisory services on the curation of active data • Provide advisory services on the technical aspects of long-term data preservation
Technical—04 Embedded Librarian	Embed librarians in the laboratory or research project
Technical—05 Data Use/Analysis	• Clean data and carry out data quality checks • Analyze and visualize data sets using Python scripts, SPSS, R, and MS Excel software
Technical—07 Metadata	Offer a service creating or transforming metadata for data or data sets
Technical—08 Repository/ Archive	Run a data repository/archive/store
Technical—09 FAIR	Support reproducibility, transparency in workflows, and research integrity
Technical—10 Publishing/ Sharing	Provide a data catalogue including your institution's research data
Technical—11 Curation/ Preservation	• Prepare data/data sets for deposit in a repository • Carry out long-term preservation of research data • Select, accession and/or deselect and deaccession data/data sets for deposit in a repository • Carry out the curation of active data • Rescue legacy data or perform data triage or forensic data recovery

in Table S3. The table contains the authors, publication years, research methods, regions, institutions, disciplines, populations, and the coded information that answered each research question. These 89 studies were published between 2012 and 2024, and as seen in Figure 2, the highest number of articles was published in 2017. However, it is important to note that the publication dates provided in the full-text documents do not always reflect the actual publication dates due to varying publication workflows among different publishers and journals. One example is Corrall et al. (2013) and Cox and Pinfield (2014), both of which were first published on their respective journal websites on 31 May 2013 and 28 June 2013 but are reflected in the in-text citations and reference list as 2013 and 2014, respectively. In terms of the research methods utilized by the studies, 30.3% ($n = 27$) of papers utilized quantitative methods, 55.1% ($n = 49$) utilized qualitative methods, and 14.6% ($n = 13$) used mixed methods.

As seen in Table S3, articles predominantly studied and surveyed libraries, librarians, researchers, students, administrators, IT staff, or faculty members. Based on Table 4, most of the studies did not specify the disciplines where RDM services were implemented. A portion of studies covered RDM services in a multidisciplinary context, while a minority of them were focused on subject-specific disciplines.

To aid analysis and synthesis of results, the studies were further broken down based on the number of institutions and number of regions examined by each study. As seen in Table 5, most studies either focused on examining RDM services provided by a single academic library and institutional context, or on large surveys or analysis across multiple libraries. Only four studies examined RDM services provided at two or three institutions to

provide a comparative-type study. Table 6 shows the breakdown of the regions that were examined by the studies, with most papers looking at RDM services provided by libraries in the United States of America (USA), followed by multi-regions and then Europe.

Overall, the characteristics of the included studies provided a holistic view of studies that examined different methodologies, sample population, and services across regions and countries.

3.3 | MMAT assessment

The results of the MMAT assessment can be found in Table S4. All 89 studies received a rating of "yes" for the

TABLE 3 Coding scheme for RQ3.

Coding scheme for RQ3	Major drivers of RDM services listed in table VII of Cox et al. (2019) study
Funder compliance	Funder compliance
Library's role	Library role—having the skills/ needing to stay relevant
Needs of researchers	Needs of researchers
Integrity	Integrity
Open science	Open science
Publishers	Publishers
Impact of research	Impact of research
Institutional policy	Institutional policy
National frameworks	REF (or equivalent)
FAIR	FAIR
Competition from commercial suppliers	Competition from commercial suppliers
Consortia	Consortia

TABLE 4 Breakdown of studies by disciplines.

Disciplines mentioned in the studies	Number of papers ($N = 89$)
Health Sciences	5 (5.6%)
Sciences	5 (5.6%)
Social Sciences & Humanities	3 (3.4%)
Multidisciplinary	21 (23.6%)
Not specified	55 (61.8%)

TABLE 5 Breakdown of studies by number of institutions studied.

Number of institutions studied	Number of papers ($N = 89$)
Single academic library	38 (42.7%)
Up to three libraries	4 (4.5%)
Four or more libraries	47 (52.8%)

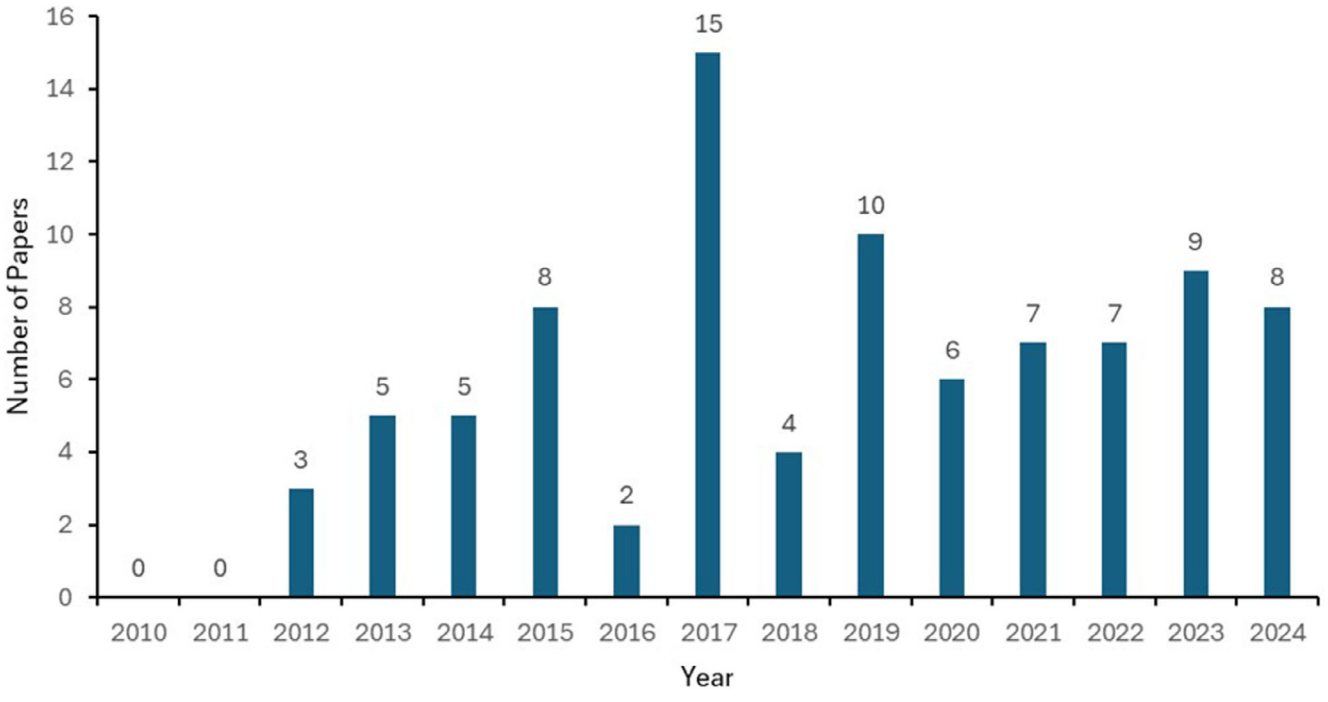

FIGURE 2 Number of papers published over time.

TABLE 6 Breakdown of regions examined by the studies.

Consolidated regions based on the studies	Example of countries mentioned in the studies (non-exhaustive)	Number of papers ($N = 89$)
Africa	Ghana, Kenya, Malawi, etc.	5 (5.6%)
Asia	China, Malaysia, India, etc.	8 (9.0%)
Australia and New Zealand	Australia and New Zealand, etc.	7 (7.9%)
Canada	Canada	4 (4.5%)
Europe	Switzerland, Belgium, Italy, France, Germany, etc.	11 (12.4%)
Middle East	Turkey, Jordan, Pakistan, etc.	4 (4.5%)
United Kingdom (UK)	United Kingdom	6 (6.7%)
United States of America (USA)	United States of America	30 (33.7%)
Multi-regions	Studies that span across multiple regions	14 (15.7%)

two main MMAT screening questions "Are there clear research questions?" and "Do the collected data allow to address the research questions?" The studies were subsequently evaluated for quality, with comments provided where necessary. Studies were all included as they had the empirical data that addressed our research questions.

3.4 | RQ1: RDM services provided by academic libraries

3.4.1 | Overview of RDM services mentioned in studies

Table 7 shows the breakdown of studies that mention specific RDM services provided by academic libraries. Based on the RDM services mentioned in the three studies, advisory-type services were more common than technical-type services. A breakdown of top advisory-type services shows 78.0% ($n = 69$) of studies mentioned the provision of RDM-related training or education, 57.0% ($n = 51$) mentioned DMP-related advisories, followed by a tie between the provision of RDM guides and data sharing or publishing-related advisories at 51.0% ($n = 45$). For technical-type services, the provision of repositories or archives for research data ranked highly with 55.0% ($n = 49$) of studies mentioning it, with the next highest being the provision of technical services related to curation or preservation at 25.0% ($n = 22$).

3.4.2 | Changes in RDM services mentioned over time

Figure 3 shows a comparison of the type of RDM services mentioned in studies over time. The trend continues to show that advisory-type services were both mentioned more commonly and disproportionately compared to technical-type services. Peaks in mentions of RDM service types occurred in 2017 and 2019, corresponding to the years where more articles were published.

The above observations are consistent with the multi-region studies that reported higher percentages for advisory-type services offered and a high percentage of provision for data repositories as technical services (Cox et al., 2017, 2019; Cox & Pinfield, 2014; Tenopir et al., 2013, 2014, 2019). This trend was also predicted by the RDM maturity model by Cox et al. (2017, 2019), which highlighted that libraries generally offered advisory-type RDM services before technical-type RDM services. Services such as training, consultations, and repositories were similar to what libraries already do and hence would naturally extend them to cover research data (Cox et al., 2019). Certain technical-type services such as data use and analysis or direct project participation had low provision as these were activities done by researchers rather than at the library (Cox et al., 2019) or were better supported by other departments or within academic faculties rather than a centralized service at the library (Cox et al., 2017).

3.4.3 | Differences in RDM services across regions

When examining RDM services provided by libraries across different regions, similar patterns were also observed. As shown in Table 8, a high frequency of advisory-type services was observed across different regions compared to technical-type services. However, some interesting observations could be extracted when looking at the region-specific case studies.

One notable observation is the lack of mention of DMP-related advisory services in the region of Africa. The lack was due to the institutional or funding context in Africa. Majority of researchers did not have DMPs (Masinde et al., 2021) as there were no formal RDM requirement or policy for doing research or for funding applications (Adekoya et al., 2024; Avuglah & Underwood, 2019). This factor relating to institutional

TABLE 7 List of RDM services mentioned in respective studies.

Codes for RQ1—Library services for RDM	*n*	%	Studies
Advisory—01 DMP	51	57.0%	Tenopir et al. (2012), Witt (2012), Corrall et al. (2013), Reilly and Dryden (2013), Varvel Jr. and Shen (2013), Antell et al. (2014), Cox and Pinfield (2014), Tenopir et al. (2014), Claibourn (2015), Davis and Cross (2015), Hiom et al. (2015), Si et al. (2015), Wang and Fong (2015), Whitmire (2015), Grynoch (2016), Sesartic and Töwe (2016), Hermans (2017), Morgan et al. (2017), Tenopir et al. (2017), Tripathi et al. (2017), Verhaar et al. (2017), Wittenberg and Elings (2017), Yoon and Schultz (2017), Yu (2017), Yu et al. (2017), Coates et al. (2018), Castle (2019), Cox et al. (2019), Féret and Cros (2019), Read et al. (2019), Si et al. (2019), Tang and Hu (2019), Tenopir et al. (2019), Yoon and Donaldson (2019), Ducas et al. (2020), Saarti et al. (2020), Töwe and Barillari (2020), Blackwood (2021), Huang et al. (2021), Bourke (2022), Howie and Kara (2022), Singh et al. (2022), Xiao et al. (2022), Amanullah and Abrizah (2023), Bhoi et al. (2023), Goldman et al. (2023), Sinha et al. (2023), Verma and Charu (2023), Öztemiz and Sahin (2024), Griffin and Janz (2024), and Howlett et al. (2024)
Advisory—02 Training/ Education	69	78.0%	Richardson et al. (2012), Tenopir et al. (2012), Corrall et al. (2013), Varvel Jr. and Shen (2013), Antell et al. (2014), Cox and Pinfield (2014), Moon (2014), Briney et al. (2015), Claibourn (2015), Davis and Cross (2015), Hiom et al. (2015), Si et al. (2015), Wang and Fong (2015), Whitmire (2015), Sesartic and Töwe (2016), Clement et al. (2017), Cox et al. (2017), Hermans (2017), Morgan et al. (2017), Southall and Scutt (2017), Steeves (2017), Surkis et al. (2017), Tripathi et al. (2017), Verhaar et al. (2017), Wittenberg and Elings (2017), Yoon and Schultz (2017), Yu (2017), Yu et al. (2017), Coates et al. (2018), Harrison (2018), Shelly and Jackson (2018), Voß and Hamrin (2018), Avuglah and Underwood (2019), Castle (2019), Cox et al. (2019), Féret and Cros (2019), Read (2019), Read et al. (2019), Si et al. (2019), Tenopir et al. (2019), Chawinga and Zinn (2020), Ducas et al. (2020), Gowen and Meier (2020), Lafferty-Hess et al. (2020), Saarti et al. (2020), Töwe and Barillari (2020), Al-Jaradat (2021), Blackwood (2021), Huang et al. (2021), Masinde et al. (2021), Nie et al. (2021), Bourke (2022), Curdt et al. (2022), Foster et al. (2022), Howie and Kara (2022), Singh et al. (2022), Xiao et al. (2022), Amanullah and Abrizah (2023), Bhoi et al. (2023), Carson et al. (2023), Goldman et al. (2023), Hrynick et al. (2023), Sinha et al. (2023), Verma and Charu (2023), Griffin and Janz (2024), Öztemiz and Sahin (2024), Rod et al. (2024), Subaveerapandiyan and Ugwulebo (2024), and Timms (2024)
Advisory—03 Guides	45	51.0%	Tenopir et al. (2012), Witt (2012), Reilly and Dryden (2013), Cox and Pinfield (2014), Moon (2014), Tenopir et al. (2014), Claibourn (2015), Hiom et al. (2015), Si et al. (2015), Grynoch (2016), Cox et al. (2017), Hermans (2017), Morgan et al. (2017), Steeves (2017), Tenopir et al. (2017), Tripathi et al. (2017), Verhaar et al. (2017), Wittenberg and Elings (2017), Yoon and Schultz (2017), Yu (2017), Yu et al. (2017), Shelly and Jackson (2018), Voß and Hamrin (2018), Castle (2019), Cox et al. (2019), Read et al. (2019), Si et al. (2019), Tenopir et al. (2019), Gowen and Meier (2020), Töwe and Barillari (2020), Al-Jaradat (2021), Huang et al. (2021), Masinde et al. (2021), Bourke (2022), Foster et al. (2022), Singh et al. (2022), Xiao et al. (2022), Amanullah and Abrizah (2023), Bhoi et al. (2023), Carson et al. (2023), Goldman et al. (2023), Martin-Melon et al. (2023), Sinha et al. (2023), Verma and Charu (2023), and Subaveerapandiyan and Ugwulebo (2024)
Advisory—05 Data Use/Analysis	43	48.0%	Richardson et al. (2012), Corrall et al. (2013), Cox and Pinfield (2014), Tenopir et al. (2014), Claibourn (2015), Davis and Cross (2015), Gordon et al. (2015), Wang and Fong (2015), Cox et al. (2017), Morgan et al. (2017), Surkis et al. (2017), Tenopir et al. (2017), Verhaar et al. (2017), Wittenberg and Elings (2017), Yoon and Schultz (2017), Yu et al. (2017), Coates et al. (2018), Avuglah and Underwood (2019), Castle (2019), Cox et al. (2019), Read (2019), Si et al. (2019), Tang and Hu (2019), Tenopir et al. (2019), Chawinga and Zinn (2020), Ducas et al. (2020), Al-Jaradat (2021), Huang et al. (2021), Masinde et al. (2021), Nie et al. (2021), Howie and Kara (2022), Singh et al. (2022), Xiao et al. (2022), Amanullah and Abrizah (2023), Bhoi et al. (2023), Goldman et al. (2023), Sinha et al. (2023), Verma and Charu (2023), Griffin and Janz (2024), Howlett et al. (2024), Öztemiz and Sahin (2024), Singh et al. (2024), and Subaveerapandiyan and Ugwulebo (2024)
Advisory—06 Active Storage	19	21.0%	Federer (2013), Reilly and Dryden (2013), Varvel Jr. and Shen (2013), Gordon et al. (2015), Wang and Fong (2015), Cox et al. (2017), Castle (2019), Cox et al. (2019), Read (2019), Si

TABLE 7 (Continued)

Codes for RQ1—Library services for RDM	*n*	%	Studies
			et al. (2019), Al-Jaradat (2021), Blackwood (2021), Huang et al. (2021), Foster et al. (2022), Singh et al. (2022), Amanullah and Abrizah (2023), Bhoi et al. (2023), Griffin and Janz (2024), and Öztemiz and Sahin (2024)
Advisory—10 Publishing/Sharing	45	51.0%	Tenopir et al. (2012), Witt (2012), Corrall et al. (2013), Varvel Jr. and Shen (2013), Antell et al. (2014), Cox and Pinfield (2014), Moon (2014), Tenopir et al. (2014), Davis and Cross (2015), Gordon et al. (2015), Hiom et al. (2015), Si et al. (2015), Whitmire (2015), Sesartic and Töwe (2016), Cox et al. (2017), Groenewegen (2017), Tenopir et al. (2017), Wittenberg and Elings (2017), Yoon and Schultz (2017), Yu (2017), Coates et al. (2018), Castle (2019), Cox et al. (2019), Si et al. (2019), Tang and Hu (2019), Tenopir et al. (2019), Yoon and Donaldson (2019), Ducas et al. (2020), Lafferty-Hess et al. (2020), Saarti et al. (2020), Töwe and Barillari (2020), Al-Jaradat (2021), Huang et al. (2021), Masinde et al. (2021), Bourke (2022), Singh et al. (2022), Amanullah and Abrizah (2023), Goldman et al. (2023), Sinha et al. (2023), Verma and Charu (2023), Yee et al. (2023), Griffin and Janz (2024), Howlett et al. (2024), Singh et al. (2024), and Subaveerapandiyan and Ugwulebo (2024)
Advisory—11 Curation/Preservation	41	46.0%	Witt (2012), Corrall et al. (2013), Federer (2013), Varvel Jr. and Shen (2013), Cox and Pinfield (2014), Claibourn (2015), Davis and Cross (2015), Gordon et al. (2015), Hiom et al. (2015), Si et al. (2015), Whitmire (2015), Sesartic and Töwe (2016), Cox et al. (2017), Tenopir et al. (2017), Yoon and Schultz (2017), Yu (2017), Coates et al. (2018), Shelly and Jackson (2018), Castle (2019), Cox et al. (2019), Read (2019), Si et al. (2019), Tang and Hu (2019), Yoon and Donaldson (2019), Chawinga and Zinn (2020), Ducas et al. (2020), Lafferty-Hess et al. (2020), Saarti et al. (2020), Töwe and Barillari (2020), Blackwood (2021), Huang et al. (2021), Masinde et al. (2021), Bourke (2022), Foster et al. (2022), Singh et al. (2022), Xiao et al. (2022), Adekoya et al. (2024), Howlett et al. (2024), Öztemiz and Sahin (2024), Singh et al. (2024), and Subaveerapandiyan and Ugwulebo (2024)
Technical—04 Embedded Librarian	13	15.0%	Federer (2013), Tenopir et al. (2014), Wang and Fong (2015), Tenopir et al. (2017), Cox et al. (2017), Cox et al. (2019), Féret and Cros (2019), Tenopir et al. (2019), Huang et al. (2021), Masinde et al. (2021), Singh et al. (2022), Goldman et al. (2023), and Hrynick et al. (2023)
Technical—05 Data Use/Analysis	8	9.0%	Cox et al. (2019), Tenopir et al. (2019), Yoon and Donaldson (2019), Chawinga and Zinn (2020), Lafferty-Hess et al. (2020), Huang et al. (2021), Singh et al. (2022), and Griffin and Janz (2024)
Technical—07 Metadata	14	16.0%	Tenopir et al. (2012), Tenopir et al. (2014), Cox et al. (2017), Tenopir et al. (2017), Shelly and Jackson (2018), Cox et al. (2019), Tenopir et al. (2019), Chawinga and Zinn (2020), Lafferty-Hess et al. (2020), Huang et al. (2021), Masinde et al. (2021), Nie et al. (2021), Bourke (2022), and Singh et al. (2022)
Technical—08 Repository/Archive	49	55.0%	Richardson et al. (2012), Tenopir et al. (2012), Witt (2012), Corrall et al. (2013), Varvel Jr. and Shen (2013), Antell et al. (2014), Cox and Pinfield (2014), Moon (2014), Tenopir et al. (2014), Briney et al. (2015), Gordon et al. (2015), Hiom et al. (2015), Wang and Fong (2015), Sesartic and Töwe (2016), Grynoch (2016), Cox et al. (2017), Groenewegen (2017), Tenopir et al. (2017), Wittenberg and Elings (2017), Yu (2017), Yu et al. (2017), Coates et al. (2018), Shelly and Jackson (2018), Voß and Hamrin (2018), Avuglah and Underwood (2019), Castle (2019), Cox et al. (2019), Féret and Cros (2019), Si et al. (2019), Tang and Hu (2019), Tenopir et al. (2019), Yoon and Donaldson (2019), Gowen and Meier (2020), Lafferty-Hess et al. (2020), Saarti et al. (2020), Töwe and Barillari (2020), Fallaw et al. (2021), Huang et al. (2021), Masinde et al. (2021), Nie et al. (2021), Bourke (2022), Curdt et al. (2022), Singh et al. (2022), Xiao et al. (2022), Amanullah and Abrizah (2023), Bhoi et al. (2023), Carson et al. (2023), Yee et al. (2023), and Griffin and Janz (2024)
Technical—09 FAIR	5	6.0%	Steeves (2017), Cox et al. (2019), Huang et al. (2021), Foster et al. (2022), and Singh et al. (2022)
Technical—10 Publishing/Sharing	12	13.0%	Tenopir et al. (2014), Morgan et al. (2017), Cox et al. (2017), Tripathi et al. (2017), Voß and Hamrin (2018), Cox et al. (2019), Chawinga and Zinn (2020), Huang et al. (2021), Masinde et al. (2021), Singh et al. (2022), Yee et al. (2023), and Griffin and Janz (2024)

(Continues)

TABLE 7 (Continued)

Codes for RQ1—Library services for RDM	*n*	%	Studies
Technical—11 Curation/ Preservation	22	25.0%	Tenopir et al. (2012), Tenopir et al. (2014), Gordon et al. (2015), Si et al. (2015), Cox et al. (2017), Tripathi et al. (2017), Yoon and Schultz (2017), Shelly and Jackson (2018), Cox et al. (2019), Tenopir et al. (2019), Yoon and Donaldson (2019), Chawinga and Zinn (2020), Ducas et al. (2020), Lafferty-Hess et al. (2020), Töwe and Barillari (2020), Fallaw et al. (2021), Huang et al. (2021), Masinde et al. (2021), Nie et al. (2021), Bourke (2022), Howie and Kara (2022), and Singh et al. (2022)
Generic mentions of RDM services	9	10.0%	Tenopir et al. (2013), Pinfield et al. (2014), Grynoch (2016), Voß and Hamrin (2018), Si et al. (2019), Ashiq et al. (2021), Nie et al. (2021), Ashiq and Warraich (2022), and Adekoya et al. (2024)

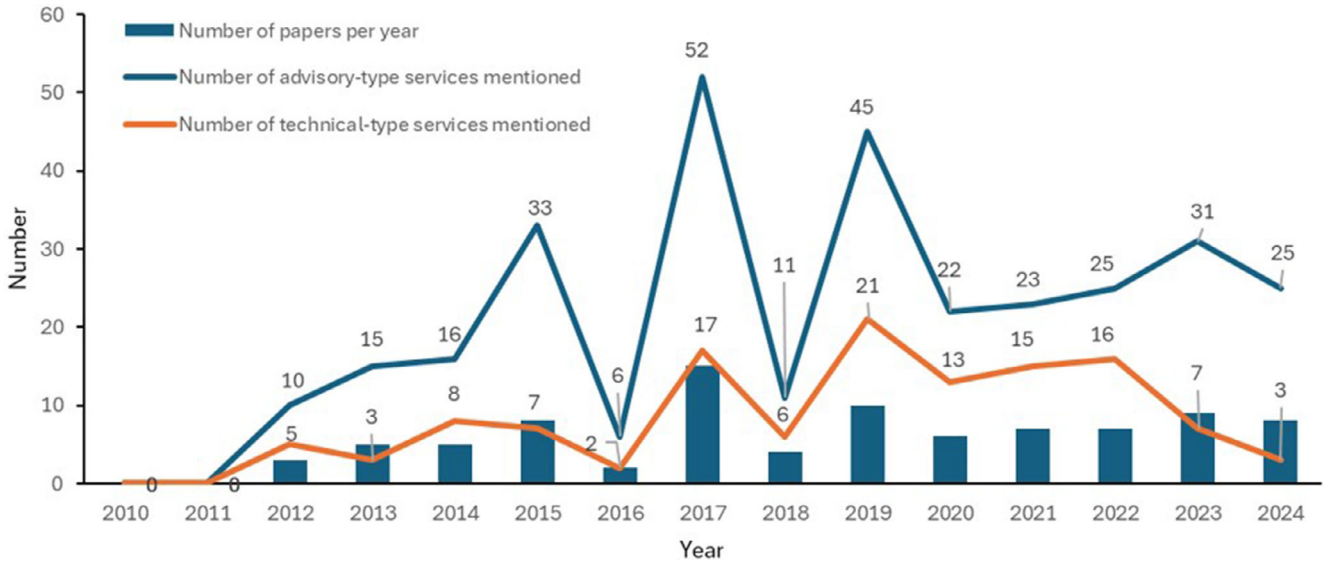

FIGURE 3 Number of papers and types of RDM services mentioned in studies per year.

policy or funding requirements influencing the provision of RDM services will be further discussed in RQ3.

For the studies focusing solely on Asia (Amanullah & Abrizah, 2023; Bhoi et al., 2023; Huang et al., 2021; Nie et al., 2021; Singh et al., 2022, 2024; Sinha et al., 2023; Xiao et al., 2022), a higher frequency of both advisory and technical-type services was observed compared to other regions. These studies were also recently published. While these studies indicated a higher frequency of RDM services provided, the studies that focused on China (Huang et al., 2021), India (Singh et al., 2022), and Southeast Asia (Sinha et al., 2023) indicated that RDM services offered were still in their infancy. A potential reason that could explain the provision of RDM services was that these libraries started with the technological solutions that provide technical-type RDM services because they were easier to implement without established institutional policies (Huang et al., 2021).

It is critical to note that while region- and country-specific studies from Australia and New Zealand, Canada, Middle East, or United Kingdom indicated no provision of technical-type RDM services, this was not the case, as reflected in the multi-region studies. Based on the surveys, technical-type RDM services were indeed provided by European libraries (Tenopir et al., 2017), Australia, Canada, New Zealand, or United Kingdom libraries (Cox et al., 2017). The provision of specific RDM-related services at each academic library was mainly predicated on several factors based on the evidence of researchers' needs, resources required to provide the service, or closeness of RDM service to existing library services provided (Cox et al., 2019). This context will be crucial when looking at the subsequent research questions to form a more comprehensive analysis of the state of RDM services in academic libraries.

TABLE 8 Breakdown of RDM services by regions as mentioned in studies.

	Africa ($N = 5$)		Asia ($N = 8$)		Australia and New Zealand ($N = 7$)		Canada ($N = 4$)		Europe ($N = 11$)		Middle East ($N = 4$)		United Kingdom ($N = 6$)		United States of America ($N = 30$)		Multi-country ($N = 14$)	
RDM services	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**
Advisory—01 DMP	0	0.0%	6	75.0%	4	57.1%	2	50.0%	8	72.7%	1	25.0%	3	50.0%	15	50.0%	12	85.7%
Advisory—02 Training/Education	4	80.0%	7	87.5%	5	71.4%	3	75.0%	9	81.8%	2	50.0%	5	83.3%	23	76.7%	11	78.6%
Advisory—03 Guides	2	40.0%	6	75.0%	3	42.9%	2	50.0%	7	63.6%	1	25.0%	3	50.0%	11	36.7%	10	71.4%
Advisory—05 Data Use/Analysis	4	80.0%	8	100.0%	5	71.4%	1	25.0%	2	18.2%	2	50.0%	2	33.3%	11	36.7%	8	57.1%
Advisory—06 Active Storage	0	0.0%	4	50.0%	0	0.0%	0	0.0%	0	0.0%	2	50.0%	1	16.7%	9	30.0%	3	21.4%
Advisory—10 Publishing/Sharing	2	40.0%	5	62.5%	2	28.6%	2	50.0%	5	45.5%	1	25.0%	3	50.0%	13	43.3%	12	85.7%
Advisory—11 Curation/Preservation	4	80.0%	4	50.0%	2	28.6%	1	25.0%	5	45.5%	1	25.0%	3	50.0%	14	46.7%	7	50.0%
Technical—04 Embedded Librarian	1	20.0%	2	25.0%	0	0.0%	0	0.0%	2	18.2%	0	0.0%	0	0.0%	4	13.3%	4	28.6%
Technical—05 Data Use/Analysis	1	20.0%	2	25.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	3	10.0%	2	14.3%
Technical—07 Metadata	2	40.0%	3	37.5%	1	14.3%	0	0.0%	2	18.2%	0	0.0%	0	0.0%	1	3.3%	5	35.7%
Technical—08 Repository/Archive	2	40.0%	6	75.0%	4	57.1%	2	50.0%	8	72.7%	0	0.0%	3	50.0%	14	46.7%	10	71.4%
Technical—09 FAIR	0	0.0%	2	25.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	2	6.7%	1	7.1%
Technical—10 Publishing/Sharing	2	40.0%	2	25.0%	1	14.3%	0	0.0%	1	9.1%	0	0.0%	0	0.0%	2	6.7%	4	28.6%
Technical—11 Curation/Preservation	2	40.0%	3	37.5%	2	28.6%	1	25.0%	2	18.2%	0	0.0%	0	0.0%	5	16.7%	7	50.0%
Generic mentions of RDM services	1	20.0%	1	12.5%	0	0.0%	1	25.0%	1	9.1%	2	50.0%	1	16.7%	0	0.0%	2	14.3%

TABLE 9 List of infrastructure, workflow, and resources supporting RDM mentioned in respective studies.

Codes for RQ2—Infrastructure, workflows, resources	*n*	%	Studies
Infrastructure—Partners	16	18.0%	Cox et al. (2017), Groenewegen (2017), Morgan et al. (2017), Tenopir et al. (2017), Shelly and Jackson (2018), Voß and Hamrin (2018), Yoon and Donaldson (2019), Lafferty-Hess et al. (2020), Saarti et al. (2020), Töwe and Barillari (2020), Blackwood (2021), Fallaw et al. (2021), Huang et al. (2021), Xiao et al. (2022), Bhoi et al. (2023), and Griffin and Janz (2024)
Infrastructure—Spaces & Facilities	7	8.0%	Claibourn (2015), Southall and Scutt (2017), Surkis et al. (2017), Si et al. (2019), Chawinga and Zinn (2020), Al-Jaradat (2021), and Masinde et al. (2021)
Infrastructure—Systems	38	43.0%	Tenopir et al. (2012), Witt (2012), Reilly and Dryden (2013), Varvel Jr. and Shen (2013), Antell et al. (2014), Moon (2014), Briney et al. (2015), Gordon et al. (2015), Hiom et al. (2015), Wang and Fong (2015), Grynoch (2016), Sesartic and Töwe (2016), Hermans (2017), Steeves (2017), Tripathi et al. (2017), Wittenberg and Elings (2017), Yu (2017), Yu et al. (2017), Avuglah and Underwood (2019), Cox et al. (2019), Si et al. (2019), Tang and Hu (2019), Yoon and Donaldson (2019), Chawinga and Zinn (2020), Ducas et al. (2020), Lafferty-Hess et al. (2020), Töwe and Barillari (2020), Fallaw et al. (2021), Huang et al. (2021), Masinde et al. (2021), Nie et al. (2021), Bourke (2022), Curdt et al. (2022), Howie and Kara (2022), Amanullah and Abrizah (2023), Carson et al. (2023), Hrynick et al. (2023), and Yee et al. (2023)
Resources—External partners	32	36.0%	Witt (2012), Federer (2013), Varvel Jr. and Shen (2013), Moon (2014), Tenopir et al. (2014), Gordon et al. (2015), Hiom et al. (2015), Si et al. (2015), Whitmire (2015), Sesartic and Töwe (2016), Cox et al. (2017), Clement et al. (2017), Hermans (2017), Southall and Scutt (2017), Steeves (2017), Tenopir et al. (2017), Wittenberg and Elings (2017), Yu (2017), Yu et al. (2017), Harrison (2018), Shelly and Jackson (2018), Voß and Hamrin (2018), Cox et al. (2019), Read et al. (2019), Ducas et al. (2020), Gowen and Meier (2020), Huang et al. (2021), Masinde et al. (2021), Nie et al. (2021), Singh et al. (2022), Xiao et al. (2022), and Amanullah and Abrizah (2023)
Resources—Internal partners	53	60.0%	Richardson et al. (2012), Tenopir et al. (2012), Witt (2012), Antell et al. (2014), Moon (2014), Pinfield et al. (2014), Tenopir et al. (2014), Briney et al. (2015), Claibourn (2015), Gordon et al. (2015), Hiom et al. (2015), Si et al. (2015), Wang and Fong (2015), Whitmire (2015), Sesartic and Töwe (2016), Cox et al. (2017), Hermans (2017), Morgan et al. (2017), Southall and Scutt (2017), Steeves (2017), Surkis et al. (2017), Tenopir et al. (2017), Tripathi et al. (2017), Verhaar et al. (2017), Wittenberg and Elings (2017), Yoon and Schultz (2017), Yu et al. (2017), Coates et al. (2018), Harrison (2018), Voß and Hamrin (2018), Avuglah and Underwood (2019), Castle (2019), Cox et al. (2019), Féret and Cros (2019), Read (2019), Read et al. (2019), Yoon and Donaldson (2019), Gowen and Meier (2020), Saarti et al. (2020), Töwe and Barillari (2020), Blackwood (2021), Fallaw et al. (2021), Huang et al. (2021), Masinde et al. (2021), Nie et al. (2021), Bourke (2022), Curdt et al. (2022), Foster et al. (2022), Howie and Kara (2022), Xiao et al. (2022), Amanullah and Abrizah (2023), Yee et al. (2023), and Öztemiz and Sahin (2024)
Resources—Personnel	27	30.0%	Tenopir et al. (2012), Federer (2013), Varvel Jr. and Shen (2013), Briney et al. (2015), Claibourn (2015), Gordon et al. (2015), Hiom et al. (2015), Grynoch (2016), Cox et al. (2017), Hermans (2017), Morgan et al. (2017), Steeves (2017), Tenopir et al. (2017), Wittenberg and Elings (2017), Coates et al. (2018), Harrison (2018), Castle (2019), Yoon and Donaldson (2019), Ducas et al. (2020), Gowen and Meier (2020), Lafferty-Hess et al. (2020), Saarti et al. (2020), Al-Jaradat (2021), Curdt et al. (2022), Foster et al. (2022), Griffin and Janz (2024), and Öztemiz and Sahin (2024)
Resources—Money & Budget	17	19.0%	Witt (2012), Federer (2013), Moon (2014), Claibourn (2015), Gordon et al. (2015), Hiom et al. (2015), Morgan et al. (2017), Harrison (2018), Read (2019), Yoon and Donaldson (2019), Saarti et al. (2020), Töwe and Barillari (2020), Foster et al. (2022), Carson et al. (2023), Goldman et al. (2023), Martin-Melon et al. (2023), and Griffin and Janz (2024)
Resources—Training & Learning	30	34.0%	Tenopir et al. (2012), Tenopir et al. (2013), Antell et al. (2014), Tenopir et al. (2014), Davis and Cross (2015), Gordon et al. (2015), Wang and Fong (2015), Cox et al.

TABLE 9 (Continued)

Codes for RQ2—Infrastructure, workflows, resources	*n*	%	Studies
			(2017), Hermans (2017), Southall and Scutt (2017), Steeves (2017), Tenopir et al. (2017), Wittenberg and Elings (2017), Yu et al. (2017), Coates et al. (2018), Castle (2019), Cox et al. (2019), Féret and Cros (2019), Read (2019), Read et al. (2019), Si et al. (2019), Tang and Hu (2019), Ducas et al. (2020), Lafferty-Hess et al. (2020), Saarti et al. (2020), Huang et al. (2021), Nie et al. (2021), Martin-Melon et al. (2023), Öztemiz and Sahin (2024), and Timms (2024)
Workflows—Revised Library Workflows	30	34.0%	Witt (2012), Reilly and Dryden (2013), Antell et al. (2014), Moon (2014), Claibourn (2015), Davis and Cross (2015), Grynoch (2016), Cox et al. (2017), Morgan et al. (2017), Steeves (2017), Tenopir et al. (2017), Wittenberg and Elings (2017), Yu et al. (2017), Coates et al. (2018), Harrison (2018), Castle (2019), Si et al. (2019), Yoon and Donaldson (2019), Ducas et al. (2020), Gowen and Meier (2020), Lafferty-Hess et al. (2020), Saarti et al. (2020), Huang et al. (2021), Xiao et al. (2022), Amanullah and Abrizah (2023), Carson et al. (2023), Goldman et al. (2023), Hrynick et al. (2023), Yee et al. (2023), and Griffin and Janz (2024)

3.5 | RQ2: Infrastructure, workflow, and resources supporting RDM services

3.5.1 | Overview of infrastructure, workflow, and resources mentioned in studies

Table 9 shows the breakdown of studies that mention the infrastructure, workflow, and resources utilized by academic libraries to support RDM services. The most common infrastructure used was systems (43.0%, $n = 38$), which also encompassed software and tools. 18.0% ($n = 16$) of the studies also mentioned that the infrastructure was provided or supported by partners, which could be internal (i.e., other units within institutions) or external (i.e., other commercial and non-commercial entities outside the institutions). Revising internal workflows (34.0%, $n = 30$) was a common way for libraries to adapt and support RDM. These revisions usually occurred in the form of expanding job roles of current personnel or forming new teams or units. The resources needed to support RDM services included partnerships (internal partners – 60.0%, $n = 53$; external partners – 36.0%, $n = 32$), training and learning (34.0%, $n = 30$), personnel (30.0%, $n = 27$) and budget (19.0%, $n = 17$).

There was a strong reliance on systems and related applications which was within expectations as robust infrastructure was essential for libraries to offer technical-type RDM services such as data repositories or archives used for data curation or preservation. This matches the findings for RQ1 which found these two services to be the most common technical-type RDM services provided by academic libraries. Predictably, most of the infrastructure mentioned in the reported studies pertained to data repositories or archives. Examples of such infrastructure provided by external partners and utilized by academic libraries included Research Data Australia (RDA) (Morgan et al., 2017; Shelly & Jackson, 2018), FigShare (Groenewegen, 2017; Shelly & Jackson, 2018; Xiao et al., 2022; Yoon & Donaldson, 2019), DSpace (Bhoi et al., 2023; Huang et al., 2021), and Dataverse (Huang et al., 2021). There was only one study which mentioned the use of a commercial software, Rosetta, for digital preservation by ETH Zurich (Töwe & Barillari, 2020). Due to Australia's proactiveness in making research data more open and accessible (Morgan et al., 2017; Shelly & Jackson, 2018), some libraries in Australia instinctively utilized RDA which is provided by ANDS, a government-funded entity and the predecessor to the current-day Australian Research Data Commons (ARDC).

To acquire the necessary personnel for supporting RDM, many libraries adjusted their internal workflows, often by re-deploying existing personnel. This practice was reported since at least 2012 (Tenopir et al., 2012), and is still ongoing worldwide according to studies published in recent years (e.g., Coates et al., 2018; Cox et al., 2017; Davis & Cross, 2015; Griffin & Janz, 2024; Huang et al., 2021; Lafferty-Hess et al., 2020; Morgan et al., 2017; Saarti et al., 2020; Tenopir et al., 2017; Wittenberg & Elings, 2017; Xiao et al., 2022). Restructuring or forming new teams was another common approach that had been adopted by libraries such as the University of Virginia Library (Claibourn, 2015), University of Melbourne Library, and Peking University Library (Si et al., 2019).

While reassigning existing personnel was a cost-effective measure, this approach was viable only if libraries also prepared their personnel well for the new role by

supporting them in training and development (Tenopir et al., 2012). Hence, for libraries offering or planning to offer RDM services, training and learning is an indispensable resource. There was a strong indication that many libraries were cognizant of this, based on the high number of studies (e.g., Davis & Cross, 2015; Ducas et al., 2020; Hermans, 2017; Nie et al., 2021; Öztemiz & Sahin, 2024; Read et al., 2019; Steeves, 2017; Tenopir et al., 2017; Yu et al., 2017) discussing personnel training opportunities, albeit to varying degrees. It was also noted that conferences and workshops were the most common form of RDM training opportunities for personnel (Castle, 2019; Coates et al., 2018; Cox et al., 2017; Davis & Cross, 2015; Öztemiz & Sahin, 2024; Saarti et al., 2020; Southall & Scutt, 2017; Tenopir et al., 2012, 2014, 2017; Wittenberg & Elings, 2017).

Besides revising library workflows, some libraries also hired new personnel to support RDM. While a small number of libraries had the budget for this (e.g., Griffin & Janz, 2024; Harrison, 2018), the more common scenario was that these new positions were either partially or fully funded by internal partners such as the Strategic Planning and Implementation Board in the case of University of Bristol (Hiom et al., 2015), Research Information Technologies (Research IT) group in the case of University of California, Berkeley (Wittenberg & Elings, 2017) and the Centre for Data Science in New York University (Steeves, 2017) or external partners such as the Australian National Data Service in the case of University of Adelaide (Morgan et al., 2017), the National Institutes of Health (NIH) in the case of University of California-Los Angeles (Federer, 2013) and the National Science Foundation and the National Institute of Child Health and Human Development in the case of New York University (Gordon et al., 2015).

The above discussion on personnel and funding underscores the importance of partnerships, a point which many studies (e.g., Ashiq et al., 2021; Cox & Pinfield, 2014; Griffin & Janz, 2024; Morgan et al., 2017; Sesartic & Töwe, 2016; Steeves, 2017; Tenopir et al., 2012, 2017; Wittenberg & Elings, 2017) had emphasized. Additionally, partnerships were essential for the development of RDM policies, which had been described as a "multi-stakeholder process" (Cox et al., 2017, p. 2186). RDM policy development requires input from all involved in the research data life cycle either as facilitators or practitioners, such as library, IT units, research offices, researchers etc. Subsequently, the execution and ongoing support of RDM services continues to require coordinated efforts from all these stakeholders (Ashiq et al., 2021; Ashiq & Warraich, 2022; Hermans, 2017). As mentioned by Donner (2023), partnerships were multi-faceted, requiring each stakeholder to know their role in RDM and establish clear communication. Therefore, establishing effective partnerships is key to the implementation of RDM services. Wittenberg and Elings (2017) suggested for libraries to monitor the evolution of such partnerships using "The Collaboration Continuum" model described by Zorich et al. (2008). The model describes the nature and level of collaborations between various parties. As the collaboration deepens, it shifts across a spectrum from left to right. Other similar models include those by Himmelman (2002) and Tamarack Institute (Weaver, 2017). Building successful partnerships is a challenging endeavor, even if all parties are keen and willing to work together (Saunders & Corning, 2020). Thus, libraries can consider using these models to assess the extent of collaborations to foster, understand dynamics of their collaborations or deepen their existing collaborations. Papers discussing the direct use or illustrate applications of the collaboration continuum models in libraries include Wittenberg and Elings (2017), Bowie (2019), Saunders and Corning (2020) and Dreher and Packard (2022).

3.5.2 | Differences in infrastructure, workflow, and resources across regions as mentioned in studies

Table 10 shows the breakdown of studies that mention the infrastructure, workflow, and resources utilized by academic libraries to support RDM services by regions. In general, the key resource for libraries across all regions was internal partnerships, followed by training and learning. For region-specific observations, European libraries exhibit a high degree of collaborations with institutional stakeholders (90.9%, $n = 10$), followed by the UK (83.3%, $n = 5$) and the USA (63.0%, $n = 19$). In Australia and New Zealand, libraries showed a greater reliance on infrastructure provided by partners (42.9%, $n = 3$). Libraries in Asia tended to adjust their internal workflows (37.5%, $n = 3$), possibly due to limited financial resources which consequentially inhibited the hiring of new personnel to support RDM.

Regarding collaborations, the study findings are congruent with the literature. It is now evident that partnerships are a vital resource for academic libraries to support RDM services, especially for those with limited budget and do not necessarily have the means to increase headcounts. Internal partnerships are also seen to be more prevalent, a finding aligned with Cox and Pinfield (2014) and Cox et al. (2017). This reason may be influenced by the specific environment and context in which libraries operate as well as their motivation for implementing RDM services.

TABLE 10 Breakdown of infrastructure, workflows, and resources supporting RDM by regions as mentioned in studies.

RQ2 codes	Africa ($N = 5$)		Asia ($N = 8$)		Australia and New Zealand ($N = 7$)		Canada ($N = 4$)		Europe ($N = 11$)		Middle East ($N = 4$)		United Kingdom ($N = 6$)		United States of America ($N = 30$)		Multi-country ($N = 14$)	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Infrastructure—Partners	0	0.0%	3	37.5%	3	42.9%	0	0.0%	4	36.4%	0	0.0%	0	0.0%	5	17.0%	1	7.1%
Infrastructure—Spaces & Facilities	2	40.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	25.0%	1	16.7%	2	7.0%	1	7.1%
Infrastructure—Systems	3	60.0%	3	37.5%	2	28.6%	3	75.0%	5	45.5%	0	0.0%	1	16.7%	14	47.0%	7	50.0%
Resources—External partners	1	20.0%	5	62.5%	2	28.6%	2	50.0%	4	36.4%	0	0.0%	3	50.0%	10	33.0%	5	35.7%
Resources—Internal partners	2	40.0%	4	50.0%	4	57.1%	1	25.0%	10	90.9%	1	25.0%	5	83.3%	19	63.0%	7	50.0%
Resources—Personnel	0	0.0%	0	0.0%	1	14.3%	2	50.0%	4	36.4%	2	50.0%	3	50.0%	13	43.0%	2	14.3%
Resources—Money & Budget	0	0.0%	0	0.0%	1	14.3%	1	25.0%	3	27.3%	0	0.0%	2	33.3%	10	33.0%	0	0.0%
Resources—Training & Learning	0	0.0%	2	25.0%	1	14.3%	1	25.0%	5	45.5%	1	25.0%	2	33.3%	10	33.0%	8	57.1%
Workflows—Revised Library Workflows	0	0.0%	3	37.5%	2	28.6%	3	75.0%	2	18.2%	0	0.0%	2	33.3%	15	50.0%	3	21.4%

Studies focusing on Australian academic libraries (Groenewegen, 2017; Morgan et al., 2017; Richardson et al., 2012; Shelly & Jackson, 2018; Yu et al., 2017) revealed a strong reliance on data infrastructure and other RDM-related resources provided by ANDS. As mentioned previously, ANDS and RDA greatly facilitated RDM works in libraries (Morgan et al., 2017; Yu et al., 2017). Where required, ANDS also provided initial funding for libraries to kickstart RDM services (Groenewegen, 2017; Morgan et al., 2017; Yu et al., 2017). This enabled the establishment of new units or the hiring of new personnel to lead RDM-related projects (Morgan et al., 2017).

3.6 | RQ3: Reasons to implement RDM services

3.6.1 | Overview of reasons for implementing RDM services mentioned in studies

Table 11 shows the breakdown of studies that mentioned the reasons for implementing RDM services. Seventy studies discussed reasons for implementing RDM services to varying extents. Library's role (36.0%, $n = 32$) was the main reason for many academic libraries to implement RDM services. This was closely followed by funder compliance (35.0%, $n = 31$), institutional policy (33.0%, $n = 29$), and needs of researchers (30.0%, $n = 27$). Other factors that received some mention include open science (13.0%, $n = 12$), FAIR (12.0%, $n = 11$), and national frameworks such as the UK Research Excellence Framework (UK REF) or equivalent (15.0%, $n = 13$).

RDM is an area where academic libraries have the potential to play a more significant role in the research process (Tenopir et al., 2012). Many libraries proactively engage in RDM, viewing it as an opportunity for: (1) enhancing libraries' image or visibility (Ashiq et al., 2021; Ashiq & Warraich, 2022; Harrison, 2018; Southall & Scutt, 2017; Tenopir et al., 2019); (2) reaffirming or strengthening libraries' value within their institutions (Clement et al., 2017; Davis & Cross, 2015; Tenopir et al., 2012, 2017); (3) reshaping the role of libraries and librarians (Harrison, 2018; Huang et al., 2021; Morgan et al., 2017). Some librarians also expressed interest in learning RDM (Tenopir et al., 2019). Incorporating RDM is seen as a natural progression for academic libraries, which were evolving beyond traditional roles into more contemporary functions (Morgan et al., 2017; Tenopir et al., 2019). This corroborates the finding discussed in RQ1 on libraries offering RDM services as a natural extension of existing library services. A point to note is

TABLE 11 List of reasons for implementing RDM services as mentioned in respective studies.

Codes for RQ3—Reasons for RDM services	*n*	%	Studies
Competition from commercial suppliers	1	1.0%	Cox et al. (2019)
Consortia	3	3.0%	Sesartic and Töwe (2016), Cox et al. (2019), and Griffin and Janz (2024)
FAIR	11	12.0%	Witt (2012), Sesartic and Töwe (2016), Verhaar et al. (2017), Shelly and Jackson (2018), Cox et al. (2019), Yoon and Donaldson (2019), Lafferty-Hess et al. (2020), Ashiq et al. (2021), Huang et al. (2021), Ashiq and Warraich (2022), and Xiao et al. (2022)
Funder compliance	31	35.0%	Richardson et al. (2012), Tenopir et al. (2012), Witt (2012), Federer (2013), Reilly and Dryden (2013), Varvel Jr. and Shen (2013), Moon (2014), Pinfield et al. (2014), Briney et al. (2015), Claibourn (2015), Hiom et al. (2015), Sesartic & Töwe (2016), Hermans (2017), Southall and Scutt (2017), Steeves (2017), Tripathi et al. (2017), Verhaar et al. (2017), Coates et al. (2018), Harrison (2018), Shelly and Jackson (2018), Voß and Hamrin (2018), Avuglah and Underwood (2019), Castle (2019), Cox et al. (2019), Féret and Cros (2019), Yoon and Donaldson (2019), Töwe and Barillari (2020), Ashiq et al. (2021), Huang et al. (2021), Bhoi et al. (2023), and Yee et al. (2023)
Impact of research	6	7.0%	Tenopir et al. (2013), Gordon et al. (2015), Si et al. (2015), Cox et al. (2019), Lafferty-Hess et al. (2020), and Huang et al. (2021)
Institutional policy	29	33.0%	Witt (2012), Cox and Pinfield (2014), Briney et al. (2015), Hiom et al. (2015), Whitmire (2015), Grynoch (2016), Cox et al. (2017), Groenewegen (2017), Hermans (2017), Southall and Scutt (2017), Tripathi et al. (2017), Verhaar et al. (2017), Shelly and Jackson (2018), Voß and Hamrin (2018), Avuglah and Underwood (2019), Cox et al. (2019), Read (2019), Si et al. (2019), Chawinga and Zinn (2020), Lafferty-Hess et al. (2020), Saarti et al. (2020), Töwe and Barillari (2020), Fallaw et al. (2021), Huang et al. (2021), Foster et al. (2022), Xiao et al. (2022), Bhoi et al. (2023), Carson et al. (2023), and Goldman et al. (2023)
Integrity	6	7.0%	Pinfield et al. (2014), Sesartic and Töwe (2016), Verhaar et al. (2017), Wittenberg and Elings (2017), Cox et al. (2019), and Huang et al. (2021)
Library's role	32	36.0%	Tenopir et al. (2012), Richardson et al. (2012), Witt (2012), Federer (2013), Reilly and Dryden (2013), Tenopir et al. (2013), Moon (2014), Pinfield et al. (2014), Claibourn (2015), Davis and Cross (2015), Gordon et al. (2015), Wang and Fong (2015), Whitmire (2015), Sesartic and Töwe (2016), Clement et al. (2017), Morgan et al. (2017), Southall and Scutt (2017), Tenopir et al. (2017), Coates et al. (2018), Harrison (2018), Voß and Hamrin (2018), Cox et al. (2019), Tenopir et al. (2019), Yoon and Donaldson (2019), Ashiq et al. (2021), Huang et al. (2021), Masinde et al. (2021), Ashiq and Warraich (2022), Singh et al. (2022), Amanullah and Abrizah (2023), Hrynick et al. (2023), and Griffin and Janz (2024)
Needs of researchers	27	30.0%	Witt (2012), Reilly and Dryden (2013), Tenopir et al. (2013), Moon (2014), Pinfield et al. (2014), Briney et al. (2015), Davis and Cross (2015), Wang and Fong (2015), Yu et al. (2017), Southall and Scutt (2017), Surkis et al. (2017), Verhaar et al. (2017), Coates et al. (2018), Cox et al. (2019), Read (2019), Si et al. (2019), Tenopir et al. (2019), Yoon and Donaldson (2019), Lafferty-Hess et al. (2020), Saarti et al. (2020), Blackwood (2021), Fallaw et al. (2021), Huang et al. (2021), Carson et al. (2023), Yee et al. (2023), Griffin and Janz (2024), and Timms (2024)
Open science	12	13.0%	Pinfield et al. (2014), Sesartic and Töwe (2016), Tenopir et al. (2017), Cox et al. (2019), Chawinga and Zinn (2020), Saarti et al. (2020), Ashiq et al. (2021), Fallaw et al. (2021), Huang et al. (2021), Nie et al. (2021), Ashiq and Warraich (2022), and Curdt et al. (2022)
Publishers	8	9.0%	Varvel Jr. and Shen (2013), Moon (2014), Hiom et al. (2015), Steeves (2017), Verhaar et al. (2017), Cox et al. (2019), Huang et al. (2021), and Yee et al. (2023)
National frameworks	13	15.0%	Varvel Jr. and Shen (2013), Moon (2014), Wang and Fong (2015), Hermans (2017), Southall and Scutt (2017), Verhaar et al. (2017), Harrison (2018), Voß and Hamrin (2018), Cox et al. (2019), Féret and Cros (2019), Ducas et al. (2020), Saarti et al. (2020), and Huang et al., 2021

that while libraries may be perceived as the most appropriate entity to offer RDM services, this is heavily dependent on the institutional contexts and availability or resources and infrastructure (Tenopir et al., 2012, 2019). Furthermore, the presence of other institutional units better equipped than the library to provide RDM services was another factor to consider (Tenopir et al., 2019). Ultimately, RDM is a multi-stakeholder process as discussed earlier in the introduction.

This review has also highlighted the library's role as the most common reason for implementing RDM services in academic libraries. However, we view it more as an impetus (i.e., push factor) and believe that various pull factors, such as funder compliance, institutional policy, or needs of researchers, work in tandem with the perceived library role to motivate the implementation of RDM services at academic libraries. For instance, the requirement for funder compliance places additional pressure on researchers to engage in RDM. Recognizing that the researchers needed help, academic libraries decided to act by providing the equivalent support (Clement et al., 2017; Tang & Hu, 2019; Varvel Jr. & Shen, 2013). Institutional policies provide a similar stimulus. As Hermans (2017) explained, policies lay the groundwork by outlining goals and directions, thereby serving as springboards for the development of RDM services within universities.

National frameworks were another significant pull factor, which was highlighted in Cox et al. (2019). These national frameworks often require researchers to perform RDM-related activities or engage in open science initiatives to demonstrate their research impact. Several established examples from the UK, Europe, USA, Canada, and Australia mentioned in the studies are listed here: UK Research Excellence Framework (UK REF); Research Councils UK (RCUK 2015) Common Principles on Data Policy; Horizon 2020 (now renamed as Horizon Europe); Netherland's Standard Evaluation Protocol (now renamed as Strategy Evaluation Protocol); Finland's Open Science and Research Roadmap; US Big Data Research and Development Initiative; the Australian Code for the Responsible Conduct of Research and the Tri-Agency Research Data Management Policy. Several case studies have cited these national mandates as the key driver for academic libraries to develop RDM services. This includes Bodleian Libraries at the University of Oxford in the UK (Southall & Scutt, 2017), Ghent University's Central Library in Belgium (Hermans, 2017), Leiden University Libraries in the Netherlands (Verhaar et al., 2017), Lille University Library in France (Féret & Cros, 2019), University of Eastern Finland (UEF) Library in Finland (Saarti et al., 2020), John Hopkins University Sheridan Libraries (Varvel Jr. & Shen, 2013) and Queen's University Library in Canada (Moon, 2014).

3.6.2 | Differences in reasons for implementing RDM services across regions

Table 12 shows the breakdown of studies that mentioned the reasons for implementing RDM services by regions. The top reasons for academic libraries implementing RDM services in the UK were funder compliance (83.3%, $n = 5$), institutional policy (50.0%, $n = 3$), and library role (50.0%, $n = 3$). For Europe, the primary driver was funder compliance (54.5%, $n = 6$), followed by institutional policy (45.5%, $n = 5$) and national frameworks (45.5%, $n = 5$), then open science (36.4%, $n = 4$). On the contrary, funder compliance (33.0%, $n = 10$) was the third most cited reason for academic libraries in the USA, trailing behind the needs of researchers (53.0%, $n = 16$) and the library's role (43.0%, $n = 13$). For Asia, library role (37.5%, $n = 3$) and institutional policy (37.5%, $n = 3$) were the main drivers, whereas funder compliance (25.0%, $n = 2$) and national frameworks (12.5%, $n = 1$) were considerably low when compared to the UK and Europe.

The above findings suggest that differences in research landscapes among regions may influence the way RDM services were being developed. The push for academic libraries in UK and Europe to initiate RDM services appears to stem from a top-down approach, that is, strong mandates from governments and funding agencies. For example, the Engineering and Physical Sciences Research Council (EPSRC) had an instrumental role in guiding higher education institutions in UK to develop RDM policies (Castle, 2019; Cox et al., 2017). In Europe, the open science movement underpins the research scene, influencing funders to impose strict requirements such as the mandatory submission of data management plans and open data sharing (Tenopir et al., 2017). The cascading effect created by these mandates on institutions and libraries to roll out RDM services was briefly mentioned by Richardson et al. (2012), Pinfield et al. (2014), Cox et al. (2017), and Southall and Scutt (2017). Conversely, in Asia, many RDM services tend to be initiated by libraries or librarians, suggesting a more ground-up approach in this region. This proactiveness was evident in Huang et al. (2021) where some academic libraries in Hong Kong went ahead to offer RDM services in the absence of institutional RDM policies. The interplay between the push factor (library role) and the pull factors (needs of researchers or institutional policies), as described earlier, appears to play a more significant role on the implementation of RDM services in some Asian academic libraries where the influence of funder mandates and national frameworks related to RDM has not been extensive (Sinha et al., 2023).

It was also noted in RQ1 that academic libraries in Asia were actively providing a variety of advisory and

TABLE 12 Breakdown of reasons for implementing RDM services by regions as mentioned in studies.

	Africa ($N = 5$)		Asia ($N = 8$)		Australia and New Zealand ($N = 7$)		Canada ($N = 4$)		Europe ($N = 11$)		Middle East ($N = 4$)		United Kingdom ($N = 6$)		United States of America ($N = 30$)		Multi-country ($N = 14$)	
RQ3 codes	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**
Competition from commercial suppliers	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	7.1%
Consortia	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	9.1%	0	0.0%	0	0.0%	1	3.0%	1	7.1%
FAIR	0	0.0%	2	25.0%	1	14.3%	0	0.0%	2	18.2%	2	50.0%	0	0.0%	3	10.0%	1	7.1%
Funder compliance	1	20.0%	2	25.0%	2	28.6%	1	25.0%	6	54.5%	1	25.0%	5	83.3%	10	33.0%	3	21.4%
Impact of research	0	0.0%	1	12.5%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	2	7.0%	3	21.4%
Institutional policy	2	40.0%	3	37.5%	2	28.6%	1	25.0%	5	45.5%	0	0.0%	3	50.0%	9	30.0%	4	28.6%
Integrity	0	0.0%	1	12.5%	0	0.0%	0	0.0%	2	18.2%	0	0.0%	1	16.7%	1	3.0%	1	7.1%
Library's role	1	20.0%	3	37.5%	2	28.6%	1	25.0%	3	27.3%	2	50.0%	3	50.0%	13	43.0%	4	28.6%
Needs of researchers	0	0.0%	1	12.5%	1	14.3%	1	25.0%	2	18.2%	0	0.0%	2	33.3%	16	53.0%	4	28.6%
Open science	1	20.0%	2	25.0%	0	0.0%	0	0.0%	4	36.4%	2	50.0%	1	16.7%	1	3.0%	1	7.1%
Publishers	0	0.0%	1	12.5%	0	0.0%	1	25.0%	1	9.1%	0	0.0%	1	16.7%	3	10.0%	1	7.1%
National frameworks	0	0.0%	1	12.5%	0	0.0%	2	50.0%	5	45.5%	0	0.0%	2	33.3%	2	7.0%	1	7.1%

technical RDM services (see Table 8). Although RDM services in this region were generally in their infancy, it was nonetheless interesting to observe the enthusiasm in exploring and offering a diverse suite of services despite being in a research environment with less stringent requirements from funding bodies and little to no RDM-related policies or strategies in place at the national levels or institutional levels (Amanullah & Abrizah, 2023; Huang et al., 2021; Nie et al., 2021; Singh et al., 2022; Sinha et al., 2023). This contrasted with academic libraries in regions like the UK and Europe, which had stronger funder mandates and a greater presence of institutional policies. Based on our studies, these libraries provided mainly advisory RDM services (with repository/archive being the only technical RDM service provided) and little to few technical RDM services.

3.7 | RQ4: Effectiveness of RDM services

3.7.1 | Challenges in evaluating effectiveness of RDM services

Evaluating the effectiveness of RDM services in libraries is a challenging and complex endeavor. Case studies like Morgan et al. (2017), Southall and Scutt (2017), and Coates et al. (2018) have illustrated that there was no "one-size-fits-all" approach, revealing that the effectiveness of RDM services can manifest in both tangible and intangible forms. It is generally easier to gather tangible evidence of impact from RDM services like instructional workshops and guides as metrics for assessing reach, engagement, quality, and knowledge retention can be obtained rather effortlessly (Coates et al., 2018). In contrast, RDM services such as those supporting data publishing, sharing, curation, and preservation processes offered intangible benefits (Coates et al., 2018) which were often demonstrated in user perceptions or other forms of descriptive feedback. Thus, the nature of RDM services, along with other complex factors such as institutional contexts, reporting objectives, and available resources, warrants a deliberate selection of the evaluation approach(es) to be adopted. A holistic evaluation of RDM services might be best achieved using a combination of quantitative and qualitative measures. Another issue to consider is the assumption that librarians are adequately competent to conduct a good service evaluation (Coates et al., 2018).

3.7.2 | Overview of studies mentioning effectiveness of RDM services

Of the 89 papers reviewed in this study, 35 discussed the effectiveness of RDM services implemented by academic libraries to support the research data life cycle to varying extents. Of these, 33 papers mentioned their RDM services were effective. The most common observation made by many libraries was the increase in awareness, visibility, and use of their RDM services by researchers which consequently enhanced their RDM competencies (Blackwood, 2021; Carson et al., 2023; Claibourn, 2015; Clement et al., 2017; Coates et al., 2018; Fallaw et al., 2021; Foster et al., 2022; Gordon et al., 2015; Hiom et al., 2015; Hrynick et al., 2023; Lafferty-Hess et al., 2020; Moon, 2014; Morgan et al., 2017; Nie et al., 2021; Read, 2019; Reilly & Dryden, 2013; Rod et al., 2024; Saarti et al., 2020; Southall & Scutt, 2017; Surkis et al., 2017; Timms, 2024; Töwe & Barillari, 2020; Verhaar et al., 2017; Whitmire, 2015; Wittenberg & Elings, 2017; Xiao et al., 2022; Yu et al., 2017). Some libraries received good feedback and acknowledgements on their RDM services (Blackwood, 2021; Castle, 2019; Clement et al., 2017; Féret & Cros, 2019; Hiom et al., 2015; Lafferty-Hess et al., 2020; Read, 2019; Surkis et al., 2017; Whitmire, 2015; Yu et al., 2017), while others noticed the visible growth of their RDM services since inception, the strengthening of partnerships with other institutional stakeholders and the increased interest from internal departments and external organizations to contribute or collaborate (Blackwood, 2021; Castle, 2019; Curdt et al., 2022; Féret & Cros, 2019; Nie et al., 2021; Read, 2019; Wittenberg & Elings, 2017). A handful of libraries also noted the success of their RDM services as a key enabler for their librarians to be seen as an important and integral part of RDM within their respective institutions (Claibourn, 2015; Davis & Cross, 2015; Federer, 2013; Féret & Cros, 2019; Read, 2019).

However, two papers reported that RDM services provided by the libraries studied were either unsatisfactory or inadequate in supporting the research data life cycle. Masinde et al. (2021) investigated researchers' perceptions of RDM services offered by a library at University of Nairobi situated in Kenya and found that an overwhelming majority of the researchers were unsatisfied with the quality of both information and technical data services. Meanwhile, Amanullah and Abrizah (2023) investigated the status of RDM services in Malaysian academic libraries and found a lack of RDM services at the planning stage (e.g., RDM and DMP training), a phase regarded by authors such as Amanullah and Abrizah (2023) and Verhaar et al. (2017) as fundamental for proper RDM implementation. Additionally, many of these academic libraries offered bibliographic reference management services and advisory services on scholarly publishing but perceived them to be data citation services and data publishing services respectively (Amanullah & Abrizah, 2023). According to their study, the presence of such misunderstandings harbored by several Malaysian

academic libraries, coupled with the absence of DMP and other services in the RDM planning phase, reflects the inadequacies of existing RDM services in supporting the entire RDM life cycle in Malaysia.

Some studies (Clement et al., 2017; Wang & Fong, 2015; Whitmire, 2015; Wittenberg & Elings, 2017) indicated that discipline-specific RDM services could be more effective than broad or discipline-agnostic RDM services in meeting the needs of researchers from various disciplines. Other studies highlighted the differing RDM needs among disciplines (Verhaar et al., 2017) or the disciplinary differences to be considered when implementing RDM services such as RDM approaches and academic practices (Castle, 2019; Tenopir et al., 2012) and the research data collected which would lead to variances in metadata standards (Wang & Fong, 2015; Whitmire, 2015). Researchers might also prefer discipline-specific RDM guidance and instruction (Whitmire, 2015; Wilson & Jefferys, 2013, as cited in Wittenberg & Elings, 2017). Notably, "subject-specific RDM support" was one of the 10 recommendations published in 2012 by the LIBER working group on e-sciences to libraries starting RDM services (Christensen-Dalsgaard et al., as cited in Castle (2019)). In addition, CESAER (an association representing the universities of science and technology in Europe) published a white paper (excluded in this study) in 2022 calling for institutions to strengthen subject-specific RDM support (Björnmalm et al., 2020). However, CESAER recognized that the optimal approach towards RDM implementation was one where an institutional-wide RDM policy was complemented with discipline-specific RDM policies and processes (Björnmalm et al., 2020). This perspective was also held by Castle (2019) in a paper which compared centralized and discipline-specific RDM services. Elsewhere, Ghent University in Belgium and Leiden University in the Netherlands adopted this approach respectively when establishing their RDM programmes or processes (Hermans, 2017; Verhaar et al., 2017) while the Bodleian Libraries at the University of Oxford exemplified it by offering a mixture of broad and discipline-specific RDM workshops (Southall & Scutt, 2017).

3.8 | Implications of the systematic review

One of the key practical implications of this review is the importance of acknowledging that not all libraries have the same level of funding, infrastructure, personnel, or necessary skills to provide the required advisory or technical RDM services within their institutions. Each library needs to examine its workflows, infrastructure, and resources to provide effective RDM services required by its institution and researchers. With all these factors at play, it is paramount that academic libraries understand their institutional, national, and regional contexts while balancing between their own library's resources, infrastructure, and workflows. Librarians interested in replicating the successes of other libraries to implement their own RDM services can look at the studies from this review to identify the type of RDM services they have implemented and understand how they have done so within their own context.

In addition, institutions and academic libraries need to evaluate their approach to providing RDM services either at a centralized or discipline-specific level. As the studies earlier mentioned, there are indications that discipline-specific RDM services could be more effective than centralized or broad RDM services. If libraries see that it is their role to provide RDM services, they will need to take the necessary actions to carry out these services effectively, such as providing resources and infrastructure, upskilling their librarians with the necessary skills to support RDM, or even seeking help through partnerships with internal or external stakeholders to fill any gaps.

Following that, this review shows how crucial partnerships are for effective RDM services. As highlighted by Cox et al. (2019), there is a fine balance between collaboration and competition of libraries and other stakeholders involved in the implementation of RDM services. Based on their RDM maturity model, more collaborations and deeper partnerships are required to provide higher-level technical RDM services. Academic libraries and other internal stakeholders within their institutions need to recognize the complementary roles they could potentially play to support RDM needs. If internal partnerships are inadequate or unavailable, academic libraries can seek partnerships with external partners at a national or regional level. As highlighted by Bryant et al. (2017), the responsibility of providing RDM support requires the attention of the entire university rather than specific units. Libraries need to seek collaborations and partnerships with other stakeholders to drive effective RDM services for their own institutions.

More efforts are also needed to recognize and encourage researchers to adopt RDM practices. While our review has looked at some of the reasons why RDM services are provided, deeper analysis into this related topic highlights the additional work required to truly enable good RDM practices. Although there is some evidence of incentives provided to researchers for good RDM practices, such as recognition through badges (Feger et al., 2021; Kidwell et al., 2016) or credit, recognition, citations, or co-authorship (Devriendt et al., 2022; Gomes

et al., 2022; Tenopir et al., 2020), reviews on this topic indicate that more can be done by all stakeholders involved to either incentivize or push for greater adoption of good RDM practices (Devriendt et al., 2021; Perrier et al., 2020; Woods & Pinfield, 2021). The push for RDM adoption, open science, and reproducible research practices requires a balance between compliance and incentives (Anger et al., 2022; Feger et al., 2020).

Lastly, as noted by Coates et al. (2018), there was little discussion in the literature on evaluating the quality or effectiveness of RDM services. This was also seen through our review, as there were comparatively fewer mentions about the effectiveness. As the demonstration of impact requires time, another recommendation is that academic libraries should endeavor to evaluate their implemented RDM services and start planning or thinking about it as early as possible within feasible means to facilitate evidence gathering. For a start, libraries and librarians may refer to Coates et al. (2018) which suggested four different methods to evaluate RDM services. This will allow academic libraries to make evidence-based decisions such as ascertaining which RDM services to maintain, optimize, or eliminate while demonstrating their value as library and information professionals.

3.9 | Limitations and future research

Several limitations exist in this review which should be addressed in future research. First, based on the inclusion and exclusion criteria of this review, only relevant peer-reviewed studies published in the English language are considered. The search was conducted through the earlier-mentioned sources using the prescribed search strategy across the specified time period. While a comprehensive search, selection, screening, and review were done, it is possible that some studies might be inadvertently missed. In addition, this specific search only retrieved a small number of studies for certain regions like Africa and the Middle East compared to the USA, which affects sample representativeness and makes analysis inconclusive for certain regions.

Second, it is important to be reminded that each research study represented a snapshot of the RDM services offered during the time of research and publication, leading to a time lag between when the data on RDM services were collected and when it was published. Additionally, the differing publication dates on the respective journals' websites and in the full-text documents of the papers retrieved, an issue highlighted earlier, complicate the tracing of developments over time. Each study would also have its own research question and focus, which led to its investigation of certain RDM services provided at the library.

Third, methodological constraints exist in this paper. As this review primarily focused on published articles, many websites and library guides were not covered. Future studies could include such sources to investigate the RDM services offered. As shown in the risk of bias assessment, the MMAT approach was employed. Despite studies that did not completely address the MMAT criteria, these studies were still included as they provided findings that address our research questions. On coding, two of the coding schemes are based on results established in Cox et al. (2019) study. While the schemes are comprehensive, there may be new RDM services or reasons for implementation that are unaccounted for. Furthermore, the RDM services, resources, reasons for providing the services, and their effectiveness must be explicitly mentioned in the publications for them to be coded and synthesized as part of the review results. It may be possible that some insights were missed out for each RQ.

Nevertheless, the results and discussion above have highlighted important findings, observations, and conclusions that are helpful for academic libraries to refer to when considering the implementation of RDM services within their own institutional contexts. Future research could examine the relationships between different stakeholders providing RDM services to identify the multitude of factors that led to their successes or failures. Additional studies could deep dive into the policies and mandates that influence RDM to better understand how RDM services can be provided in an effective manner.

4 | CONCLUSION

Based on the synthesis of findings and results from RQ1 to RQ3, national frameworks and institutional contexts were observed to be strong pull factors that require academic libraries to provide RDM services. These requirements drive the researchers' needs for RDM, who, in turn, look towards the library for such RDM services or support. Findings from RQ4 also highlighted that these RDM services provided helped to increase the competencies of researchers in various aspects of RDM.

While libraries acknowledge their role as integral in the research data life cycle, librarians also need to recognize that strong infrastructure, skills, and partnerships are required to implement successful RDM services. Many case studies and examples of successful RDM service implementations underscore the importance of strong, effective partnerships between the academic library and other departments such as the university's research or academic offices, faculty departments, and IT departments. In some scenarios, the provision of IT

systems, infrastructure, or repositories stemming from such partnerships or by national-level providers created an efficient and robust system for storing, archiving, and sharing research data.

In conclusion, managing research data is important as it further showcases research impact and research output of institutions. With the evolving interdisciplinary research landscape and use of generative artificial intelligence, effective RDM will aid in the reproducibility and replicability of science. Robust and effective RDM practices will also help to ensure integrity and transparency of research findings. Academic and research libraries will continue to play an integral role in RDM, and the insights from this review can help to facilitate librarians, university administrators, researchers, funding agencies, and other stakeholders in implementing RDM services in their respective institutional contexts or contributing to the research data life cycle.

ACKNOWLEDGMENTS

The authors would like to thank all colleagues, editors, and reviewers for their constructive comments.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ORCID

Richard Cheng Yong Ho https://orcid.org/0000-0001-7477-6184
Suei Nee Wong https://orcid.org/0000-0003-3086-2480
Patsy Chia https://orcid.org/0009-0005-9468-3387
Chris Tang https://orcid.org/0009-0000-1543-3958

REFERENCES

ACRL Research Planning and Review Committee. (2024). 2024 top trends in academic libraries: A review of the trends and issues. *College & Research Libraries News*, *85*(6), 231. https://doi.org/10.5860/crln.85.6.231

Adekoya, C. O., Guobiazor, I. R., Busayo, I. O., & Alade, A. V. (2024). Research data management services among librarians in Nigerian universities. *Information Development*. https://doi.org/10.1177/02666669231222460

Al-Jaradat, O. M. (2021). Research data management (RDM) in Jordanian public university libraries: Present status, challenges and future perspectives. *Journal of Academic Librarianship*, *47*(5), 102378. https://doi.org/10.1016/j.acalib.2021.102378

Amanullah, S. W., & Abrizah, A. (2023). The landscape of research data management services in Malaysian academic libraries: Librarians' practices and roles. *Electronic Library*, *41*(1), 63–86. https://doi.org/10.1108/EL-06-2022-0135

Andrikopoulou, A., Rowley, J., & Walton, G. (2022). Research data management (RDM) and the evolving identity of academic libraries and librarians: A literature review. *New Review of Academic Librarianship*, *28*(4), 349–365. https://doi.org/10.1080/13614533.2021.1964549

Anger, M., Wendelborn, C., Winkler, E. C., & Schickhardt, C. (2022). Neither carrots nor sticks? Challenges surrounding data sharing from the perspective of research funding agencies—A qualitative expert interview study. *PLoS One*, *17*(9), e0273259. https://doi.org/10.1371/journal.pone.0273259

Antell, K., Foote, J. B., Turner, J., & Shults, B. (2014). Dealing with data: Science librarians' participation in data management at Association of Research Libraries institutions. *College & Research Libraries*, *75*(4), 557–574. https://doi.org/10.5860/crl.75.4.557

Ashiq, M., Saleem, Q. U. A., & Asim, M. (2021). The perception of library and information science (LIS) professionals about research data management services in university libraries of Pakistan. *Libri*, *71*(3), 239–249. https://doi.org/10.1515/libri-2020-0098

Ashiq, M., Usmani, M. H., & Naeem, M. (2022). A systematic literature review on research data management practices and services. *Global Knowledge, Memory and Communication*, *71*(8/9), 649–671. https://doi.org/10.1108/GKMC-07-2020-0103

Ashiq, M., & Warraich, N. F. (2022). Librarian's perception on data librarianship core concepts: A survey of motivational factors, challenges, skills and appropriate trainings platforms. *Library Hi Tech*, *42*, 849–866. https://doi.org/10.1108/lht-12-2021-0487

Ashiq, M., & Warraich, N. F. (2023). A systematized review on data librarianship literature: Current services, challenges, skills, and motivational factors. *Journal of Librarianship and Information Science*, *55*(2), 414–433. https://doi.org/10.1177/09610006221083675

Avuglah, B. K., & Underwood, P. G. (2019). *Research data management (RDM) capabilities at the University of Ghana, Legon* (Library Philosophy and Practice 2019).

Ball, A. (2012). *Review of data management lifecycle models* (Unpublished manuscript). University of Bath, UK. Retrieved from https://purehost.bath.ac.uk/ws/portalfiles/portal/206543/redm1rep120110ab10.pdf

Bhoi, N. K., Patel, J., & Dutta, B. (2023). State of research data management practices in the top-ranked higher education institutions in India. *International Information and Library Review*, *55*(4), 283–301. https://doi.org/10.1080/10572317.2023.2167051

Bishop, W., Collier, H., Orehek, A. M., & Ihli, M. (2021). Potential roles for science librarians in research data management: A gap analysis. *Issues in Science and Technology Librarianship*, *98*, 1–17. https://doi.org/10.29173/istl2602

Björnmalm, M., Cappelluti, F., Dunning, A., Gheorghe, D., Goraczek, M. Z., Hausen, D., Hermann, S., Kraft, A., Lavanchy, P. M., Prisecaru, T., Sánchez, B., & Strötgen, R. (2020). *Advancing research data management in universities of science and technology* (White Paper). Zenodo. https://doi.org/10.5281/zenodo.3665372

Blackwood, E. (2021). Outside the R1: Equitable data management at the undergraduate level. *IASSIST Quarterly*, *45*(2), 1–12. https://doi.org/10.29173/iq1011

Bourke, T. (2022). Bibliographic control of research datasets: Reflections from the EUI library. *JLIS.it*, *13*(1), 321–334. https://doi.org/10.4403/jlis.it-12723

Bowie, A. (2019). *Digital collaboration and educational resources: National Library of Scotland and education sector case study* (Masters dissertation, University of Strathclyde). University of

Strathclyde Computer and Information Sciences-local cis. Retrieved from https://local.cis.strath.ac.uk/wp/extras/msctheses/papers/strath_cis_publication_2748.pdf

Briney, K., Goben, A., & Zilinski, L. (2015). Do you have an institutional data policy? A review of the current landscape of library data services and institutional data policies. *Journal of Librarianship & Scholarly Communication*, *3*(2), 1–25. https://doi.org/10.7710/2162-3309.1232

Brochu, L., & Burns, J. (2019). Librarians and research data management—A literature review: Commentary from a senior professional and a new professional librarian. *New Review of Academic Librarianship*, *25*(1), 49–58. https://doi.org/10.1080/13614533.2018.1501715

Bryant, R., Lavoie, B., & Malpas, C. (2017). *The realities of research data management part one a tour of the research data management (RDM) service space*. Online Computer Library Centre. Retrieved from http://www.oclc.org/content/dam/research/publications/2017/oclcresearch-research-data-management-servicespace-tour-2017-a4.pdf

Carson, M. B., Gonzales, S., Shaw, P., Schneider, D., & Holmes, K. (2023). Bridging the gap: A library-based collaboration to enhance data skills for clinical researchers. *Learning Health Systems*, *7*(2), e10339. https://doi.org/10.1002/lrh2.10339

Castle, C. (2019). Getting the central RDM message across: A case study of central versus discipline-specific Research Data Services (RDS) at the University of Cambridge. *Libri*, *69*(2), 105–116. https://doi.org/10.1515/libri-2018-0064

Chawinga, W. D., & Zinn, S. (2020). Research data management in universities: A comparative study from the perspectives of librarians and management. *International Information and Library Review*, *53*, 97–111. https://doi.org/10.1080/10572317.2020.1793448

Claibourn, M. P. (2015). Bigger on the inside: Building research data services at the University of Virginia. *Insights: The UKSG Journal*, *28*(2), 100–106. https://doi.org/10.1629/uksg.239

Clement, R., Blau, A., Abbaspour, P., & Gandour-Rood, E. (2017). Team-based data management instruction at small liberal arts colleges. *IFLA Journal*, *43*(1), 105–118. https://doi.org/10.1177/0340035216678239

Coates, H. L., Carlson, J., Clement, R., Henderson, M., Johnston, L. R., & Shorish, Y. (2018). How are we measuring up? Evaluating research data services in academic libraries. *Journal of Librarianship & Scholarly Communication*, *6*, 1–33. https://doi.org/10.7710/2162-3309.2226

Cooke, A., Smith, D., & Booth, A. (2012). Beyond PICO: The SPIDER tool for qualitative evidence synthesis. *Qualitative Health Research*, *22*(10), 1435–1443. https://doi.org/10.1177/1049732312452938

Corrall, S., Kennan, M. A., & Afzal, W. (2013). Bibliometrics and research data management services: Emerging trends in library support for research. *Library Trends*, *61*(3), 636–674. https://doi.org/10.1353/lib.2013.0005

Cox, A. M., Kennan, M. A., Lyon, L., & Pinfield, S. (2017). Developments in research data management in academic libraries: Towards an understanding of research data service maturity. *Journal of the Association for Information Science and Technology*, *68*(9), 2182–2200. https://doi.org/10.1002/asi.23781

Cox, A. M., Kennan, M. A., Lyon, L., Pinfield, S., & Sbaffi, L. (2019). Maturing research data services and the transformation of academic libraries. *Journal of Documentation*, *75*(6), 1432–1462. https://doi.org/10.1108/JD-12-2018-0211

Cox, A. M., & Pinfield, S. (2014). Research data management and libraries: Current activities and future priorities. *Journal of Librarianship and Information Science*, *46*(4), 299–316. https://doi.org/10.1177/0961000613492542

Cox, A. M., & Tam, W. W. T. (2018). A critical analysis of lifecycle models of the research process and research data management. *Aslib Journal of Information Management*, *70*(2), 142–157. https://doi.org/10.1108/AJIM-11-2017-0251

Cox, A. M., & Verbaan, E. (2016). How academic librarians, IT staff, and research administrators perceive and relate to research. *Library and Information Science Research*, *38*(4), 319–326. https://doi.org/10.1016/j.lisr.2016.11.004

Curdt, C., Dierkes, J., & Kloppenburg, S. (2022). RDM in a decentralised university ecosystem—A case study of the University of Cologne. *Data Science Journal*, *21*(1), 1–8. https://doi.org/10.5334/dsj-2022-020

Davis, H. M., & Cross, W. M. (2015). Using a data management plan review service as a training ground for librarians. *Journal of Librarianship & Scholarly Communication*, *3*(2), 1–20. https://doi.org/10.7710/2162-3309.1243

Devriendt, T., Borry, P., & Shabani, M. (2022). Credit and recognition for contributions to data-sharing platforms among cohort holders and platform developers in Europe: Interview study. *Journal of Medical Internet Research*, *24*(1), e25983. https://doi.org/10.2196/25983

Devriendt, T., Shabani, M., & Borry, P. (2021). Data sharing in biomedical sciences: A systematic review of incentives. *Biopreservation and Biobanking*, *19*(3), 219–227. https://doi.org/10.1089/bio.2020.0037

Donner, E. K. (2023). Research data management systems and the organization of universities and research institutes: A systematic literature review. *Journal of Librarianship and Information Science*, *55*(2), 261–281. https://doi.org/10.1177/09610006211070282

Dreher, S., & Packard, A. (2022). *Pieced together: Community engagement through collaboration* (pp. 53–61). Swarthmore College, Library Staff Works. Retrieved from https://works.swarthmore.edu/sta-libraries/118/

Ducas, A., Michaud-Oystryk, N., & Speare, M. (2020). Reinventing ourselves: New and emerging roles of academic librarians in Canadian research-intensive universities. *College and Research Libraries*, *81*(1), 43–65. https://doi.org/10.5860/crl.81.1.43

Fallaw, C., Schmitt, G., Luong, H., Colwell, J., & Strutz, J. (2021). Institutional data repository development, a moving target. *Code4Lib Journal*, *51*. https://journal.code4lib.org/articles/15821

Fearon, D., Gunia, B., Lake, S., Pralle, B. E., & Sallans, A. L. (2013). *Research data management services (SPEC Kit No. 334)*. Association of Research Libraries. Retrieved from http://publications.arl.org/Research-Data-Management-Services-SPEC-Kit-334

Federer, L. (2013). The librarian as research informationist: A case study. *Journal of the Medical Library Association*, *101*(4), 298–302. https://doi.org/10.3163/1536-5050.101.4.011

Feger, S. S., Wozniak, P. W., Lischke, L., & Schmidt, A. (2020). "Yes, I comply!": Motivations and practices around research data management and reuse across scientific fields. *Proceedings of the ACM on Human-Computer Interaction*, *4*(CSCW2), 1–26. https://doi.org/10.1145/3415212

Feger, S. S., Woźniak, P. W., Niess, J., & Schmidt, A. (2021). Tailored science badges: Enabling new forms of research interaction. *Designing Interactive Systems Conference*, *2021*, 576–588. https://doi.org/10.1145/3461778.3462067

Féret, R., & Cros, M. (2019). The embedded research librarian: A project partner. *LIBER Quarterly*, *29*(1), 1–20. https://doi.org/10.18352/lq.10304

Foster, E. D., Whipple, E. C., & Rios, G. R. (2022). Implementing an institution-wide electronic lab notebook initiative. *Journal of the Medical Library Association*, *110*(2), 222–227. https://doi.org/10.5195/jmla.2022.1407

Goldman, J., Muilenburg, J., Schorr, A. N., Ossom-Williamson, P., & Uribe-Lacy, C. J. (2023). Trends in research data management and academic health sciences libraries. *Medical Reference Services Quarterly*, *42*(3), 273–293. https://doi.org/10.1080/02763869.2023.2218776

Gomes, D. G. E., Pottier, P., Crystal-Ornelas, R., Hudgins, E. J., Foroughirad, V., Sánchez-Reyes, L. L., Turba, R., Martinez, P. A., Moreau, D., Bertram, M. G., Smout, C. A., & Gaynor, K. M. (2022). Why don't we share data and code? Perceived barriers and benefits to public archiving practices. *Proceedings of the Royal Society B: Biological Sciences*, *289*(1987), 20221113. https://doi.org/10.1098/rspb.2022.1113

Gordon, A. S., Millman, D. S., Steiger, L., Adolph, K. E., & Gilmore, R. O. (2015). Researcher-library collaborations: Data repositories as a service for researchers. *Journal of Librarianship and Scholarly Communication*, *3*(2), eP1238. https://doi.org/10.7710/2162-3309.1238

Gowen, E., & Meier, J. J. (2020). Research data management services and strategic planning in libraries today: A longitudinal study. *Journal of Librarianship and Scholarly Communication*, *8*(1), 2336. https://doi.org/10.7710/2162-3309.2336

Griffin, T. M., & Janz, M. (2024). Research data management sustainability: Services, infrastructure, accountability, and planning. *Portal: Libraries and the Academy*, *24*(2), 305–342. https://doi.org/10.1353/pla.2024.a923709

Groenewegen, D. (2017). Yesterday and today: Reflecting on past practice to help build and strengthen the researcher partnership at Monash University. *New Review of Academic Librarianship*, *23*(2-3), 171–184. https://doi.org/10.1080/13614533.2017.1336637

Grynoch, T. (2016). Implementing research data management services in a Canadian context. *Dalhousie Journal of Interdisciplinary Management*, *12*, 1–24. https://doi.org/10.5931/djim.v12.i1.6458

Harrison, R. (2018). Reshaping academic librarianship in the context of twenty-first century scholarly communications and information fluency: A case study of the scholarly communications management team at Imperial College London library services. *New Review of Academic Librarianship*, *24*(3–4), 351–364. https://doi.org/10.1080/13614533.2018.1519490

Hermans, E. (2017). Academic libraries meet research data management: A case study of the University of Ghent's central library's practices. *Citaliste*, *16*(30), 4–12.

Himmelman, A. T. (2002). *Collaboration defined: A developmental continuum of change strategies*. Himmelman Consulting. Retrieved from https://tennessee.edu/wp-content/uploads/2019/07/Himmelman-Collaboration-for-a-Change.pdf

Hiom, D., Fripp, D., Gray, S., Snow, K., & Steer, D. (2015). Research data management at the University of Bristol: Charting a course from project to service. *Program*, *49*(4), 475–493. https://doi.org/10.1108/PROG-02-2015-0019

Hong, Q. N., Fàbregues, S., Bartlett, G., Boardman, F., Cargo, M., Dagenais, P., Gagnon, M.-P., Griffiths, F., Nicolau, B., O'Cathain, A., Rousseau, M.-C., Vedel, I., & Pluye, P. (2018). The Mixed Methods Appraisal Tool (MMAT) version 2018 for information professionals and researchers. *Education for Information*, *34*(4), 285–291. https://doi.org/10.3233/EFI-180221

Howie, J., & Kara, H. (2022). Research support in New Zealand university libraries. *New Review of Academic Librarianship*, *28*(1), 7–36. https://doi.org/10.1080/13614533.2019.1700535

Howlett, A., Colla, E., & Joyce, R. (2024). Toward redefining library research support services in Australia and Aotearoa New Zealand: An evidence-based practice approach. *New Review of Academic Librarianship*, *30*, 24–51. https://doi.org/10.1080/13614533.2024.2306360

Hrynick, M. G., Anderson, A. W., Moore, E. C., & Meade, M. (2023). Embedding librarians in archaeological field schools. *Advances in Archaeological Practice*, *11*(4), 434–441. https://doi.org/10.1017/aap.2023.17

Huang, Y., Cox, A. M., & Sbaffi, L. (2021). Research data management policy and practice in Chinese university libraries. *Journal of the Association for Information Science and Technology*, *72*(4), 493–506. https://doi.org/10.1002/asi.24413

Kidwell, M. C., Lazarević, L. B., Baranski, E., Hardwicke, T. E., Piechowski, S., Falkenberg, L.-S., Kennett, C., Slowik, A., Sonnleitner, C., Hess-Holden, C., Errington, T. M., Fiedler, S., & Nosek, B. A. (2016). Badges to acknowledge open practices: A simple, low-cost, effective method for increasing transparency. *PLoS Biology*, *14*(5), e1002456. https://doi.org/10.1371/journal.pbio.1002456

Lafferty-Hess, S., Rudder, J., Downey, M., Ivey, S., Darragh, J., & Kati, R. (2020). Conceptualizing data curation activities within two academic libraries. *Journal of Librarianship and Scholarly Communication*, *8*(1), 2347. https://doi.org/10.7710/2162-3309.2347

Liu, L., & Liu, W. (2023). The engagement of academic libraries in open science: A systematic review. *Journal of Academic Librarianship*, *49*(3), 102711. https://doi.org/10.1016/j.acalib.2023.102711

Martin-Melon, R., Hernández-Pérez, T., & Martínez-Cardama, S. (2023). Research Data Services (RDS) in Spanish academic libraries. *Journal of Academic Librarianship*, *49*(4), 102732. https://doi.org/10.1016/j.acalib.2023.102732

Masinde, J. M., Jing, C., & Muthee, D. W. (2021). Researchers' perceptions of research data management activities at an academic library in a developing country. *International Journal of Library & Information Services (IJLIS)*, *10*(2), 1–17. https://doi.org/10.4018/IJLIS.20210701.oa11

Moon, J. (2014). Developing a research data management service—A case study. *Partnership*, *9*(1), 1–14. https://doi.org/10.21083/partnership.v9i1.2988

Morgan, A., Duffield, N., & Hall, L. W. (2017). Research data management support: Sharing our experiences. *Journal of the Australian Library and Information Association*, *66*(3), 299–305. https://doi.org/10.1080/24750158.2017.1371911

Mthembu, M., & Mbatha, L. S. (2022). Supporting data preservation through institutional repositories of the academic libraries in

South Africa: A case study of three academic libraries. In *Innovative technologies for enhancing knowledge access in academic libraries* (pp. 176–195). IGI Global. https://doi.org/10.4018/978-1-6684-3364-5.ch011

Nie, H., Luo, P., & Fu, P. (2021). Research data management implementation at Peking university library: Foster and promote open science and open data. *Data Intelligence*, *3*(1), 189–204. https://doi.org/10.1162/dint_a_00088

OECD. (2015). *Making open science a reality* (OECD Science, Technology and Industry Policy Papers, No. 25). https://doi.org/10.1787/5jrs2f963zs1-en

Oo, C. Z., Chew, A. W., Wong, A. L. H., Gladding, J., & Stenstrom, C. (2022). Delineating the successful features of research data management training: A systematic review. *International Journal for Academic Development*, *27*(3), 249–264. https://doi.org/10.1080/1360144X.2021.1898399

Öztemiz, S., & Sahin, H. N. (2024). The role of research university libraries in research data management: The case of Turkiye. *Information Development*. https://doi.org/10.1177/02666669231224430

Page, M. J., Moher, D., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … McKenzie, J. E. (2021). PRISMA 2020 explanation and elaboration: Updated guidance and exemplars for reporting systematic reviews. *BMJ (Clinical Research Ed.)*, *372*, n160. https://doi.org/10.1136/bmj.n160

Perrier, L., Blondal, E., & MacDonald, H. (2020). The views, perspectives, and experiences of academic researchers with data sharing and reuse: A meta-synthesis. *PLoS One*, *15*(2), e0229182. https://doi.org/10.1371/journal.pone.0229182

Pinfield, S., Cox, A. M., & Smith, J. (2014). Research data management and libraries: Relationships, activities, drivers and influences. *PLoS One*, *9*(12), e114734. https://doi.org/10.1371/journal.pone.0114734

Read, K. B. (2019). Adapting data management education to support clinical research projects in an academic medical center. *Journal of the Medical Library Association*, *107*(1), 89–97. https://doi.org/10.5195/jmla.2019.580

Read, K. B., Koos, J., Miller, R. S., Miller, C. F., Phillips, G. A., Scheinfeld, L., & Surkis, A. (2019). A model for initiating research data management services at academic libraries. *Journal of the Medical Library Association*, *107*(3), 432–441. https://doi.org/10.5195/jmla.2019.545

Reilly, M., & Dryden, A. R. (2013). Building an online Data Management Plan tool. *Journal of Librarianship and Scholarly Communication*, *1*(3), 1–11. https://doi.org/10.7710/2162-3309.1066

Richardson, J., Nolan-Brown, T., Loria, P., & Bradbury, S. (2012). Library research support in Queensland: A survey. *Australian Academic & Research Libraries*, *43*(4), 258–277.

Rod, A. B., Hervieux, S., & Lee, N. (2024). Evaluating an instructional intervention for research data management training. *Evidence Based Library and Information Practice*, *19*(1), 114–131. https://doi.org/10.18438/eblip30439

Saarti, J., Rosti, T., & Silvennoinen-Kuikka, H. (2020). Implementing open science policies into library processes—Case study of the University of Eastern Finland Library. *Liber Quarterly*, *30*(1), 1–20. https://doi.org/10.18352/lq.10336

Safdar, M., Rehman, S. U., Arif, M., & Ashiq, M. (2023). Research data services in libraries: A systematic literature review. *Information Discovery and Delivery*, *51*(2), 151–165. https://doi.org/10.1108/IDD-04-2021-0044

Saunders, L., & Corning, S. (2020). From cooperation to collaboration: toward a framework for deepening library partnerships. *Journal of Library Administration*, *60*(5), 453–469. https://doi.org/10.1108/01930826.2020.1729623

Sesartic, A., & Töwe, M. (2016). Research data services at ETH-Bibliothek. *IFLA Journal*, *42*(4), 284–291. https://doi.org/10.1177/0340035216674971

Shelly, M., & Jackson, M. (2018). Research data management compliance: Is there a bigger role for university libraries? *Journal of the Australian Library and Information Association*, *67*(4), 394–410. https://doi.org/10.1080/24750158.2018.1536690

Si, L., Xing, W., Zhuang, X., Hua, X., & Zhou, L. (2015). Investigation and analysis of research data services in university libraries. *Electronic Library*, *33*(3), 417–449. https://doi.org/10.1108/EL-07-2013-0130

Si, L., Zeng, Y., Guo, S., & Zhuang, X. (2019). Investigation and analysis of research support services in academic libraries. *Electronic Library*, *37*(2), 281–301. https://doi.org/10.1108/EL-06-2018-0125

Singh, R. K., Bharti, S., & Madalli, D. P. (2022). Evaluation of Research Data Management (RDM) services in academic libraries of India: A triangulation approach. *The Journal of Academic Librarianship*, *48*(6), 102586. https://doi.org/10.1016/j.acalib.2022.102586

Singh, R. K., Raj, R., & Madalli, D. P. (2024). Investigation of Research Support Services (RSS) in academic libraries of India. *Journal of Librarianship and Information Science*. https://doi.org/10.1177/09610006241245714

Sinha, P., Subaveerapandiyan, A., & Sinha, M. K. (2023). Research data management services in academic libraries: A comparative study of South Asia and Southeast Asia. *Global Knowledge, Memory and Communication*, *74*(3–4), 777–793. https://doi.org/10.1108/GKMC-01-2023-0033

Southall, J., & Scutt, C. (2017). Training for research data management at the Bodleian libraries: National contexts and local implementation for researchers and librarians. *New Review of Academic Librarianship*, *23*(2–3), 303–322. https://doi.org/10.1080/13614533.2017.1318766

Steeves, V. (2017). Reproducibility librarianship. *Collaborative Librarianship*, *9*(2), 80–89.

Subaveerapandiyan, A., & Ugwulebo, J. E. (2024). Research data management in selected East African libraries: A survey. *IFLA Journal*, *50*, 341–353. https://doi.org/10.1177/03400352231226214

Surkis, A., LaPolla, F. W., Contaxis, N., & Read, K. B. (2017). Data day to day: Building a community of expertise to address data skills gaps in an academic medical center. *Journal of the Medical Library Association*, *105*(2), 185–191. https://doi.org/10.5195/jmla.2017.35

Surkis, A., & Read, K. (2015). Research data management. *Journal of the Medical Library Association*, *103*(3), 154–156. https://doi.org/10.3163/1536-5050.103.3.011

Tang, R., & Hu, Z. (2019). Providing Research Data Management (RDM) services in libraries: Preparedness, roles, challenges, and training for RDM practice. *Data and Information Management*, *3*(2), 84–101. https://doi.org/10.2478/dim-2019-0009

Tenopir, C., Allard, S., Sandusky, R. J., Lundeen, A., & Baird, L. N. (2019). Academic librarians and research data services: Attitudes and practices. *ITlib*, *1*, 24–37.

Tenopir, C., Birch, B., & Allard, S. (2012). *Academic libraries and research data services: Current practices and plans for the future* (ACRL White Paper). Association of College and Research Libraries. Retrieved from http://www.ala.org/acrl/sites/ala.org.acrl/files/content/publications/whitepapers/Tenopir_Birch_Allard.pdf

Tenopir, C., Rice, N. M., Allard, S., Baird, L., Borycz, J., Christian, L., Grant, B., Olendorf, R., & Sandusky, R. J. (2020). Data sharing, management, use, and reuse: Practices and perceptions of scientists worldwide. *PLoS One*, *15*(3), e0229003. https://doi.org/10.1371/journal.pone.0229003

Tenopir, C., Sandusky, R. J., Allard, S., & Birch, B. (2013). Academic librarians and research data services: Preparation and attitudes. *IFLA Journal*, *39*(1), 70–78. https://doi.org/10.1177/0340035212473089

Tenopir, C., Sandusky, R. J., Allard, S., & Birch, B. (2014). Research data management services in academic research libraries and perceptions of librarians. *Library and Information Science Research*, *36*(2), 84–90. https://doi.org/10.1016/j.lisr.2013.11.003

Tenopir, C., Talja, S., Horstmann, W., Late, E., Hughes, D., Pollock, D., Schmidt, B., Baird, L., Sandusky, R. J., & Allard, S. (2017). Research data services in European academic research libraries. *LIBER Quarterly*, *27*(1), 23–44. https://doi.org/10.18352/lq.10180

Timms, G. (2024). Introducing undergraduates to research data management: A marine science case study-based asynchronous express course. *Science and Technology Libraries*, *43*(1), 78–97. https://doi.org/10.1080/0194262X.2023.2237077

Töwe, M., & Barillari, C. (2020). Who does what?—Research data management at ETH Zurich. *Data Science Journal*, *19*(1), 1–6. https://doi.org/10.5334/DSJ-2020-036

Tripathi, M., Shukla, A., & Sonker, S. K. (2017). Research data management practices in university libraries: A study. *DESIDOC Journal of Library & Information Technology*, *37*(6), 417–424. https://doi.org/10.14429/djlit.37.6.11336

Varvel, V. E., Jr., & Shen, Y. (2013). Data management consulting at the Johns Hopkins University. *New Review of Academic Librarianship*, *19*(3), 224–245. https://doi.org/10.1080/13614533.2013.768277

Verbaan, E., & Cox, A. M. (2014). Occupational sub-cultures, jurisdictional struggle and third space: theorising professional service responses to research data management. *Journal of Academic Librarianship*, *40*(3–4), 211–219. https://doi.org/10.1016/j.acalib.2014.02.008

Verhaar, P., Schoots, F., Sesink, L., & Frederiks, F. (2017). Fostering effective data management practices at Leiden university. *LIBER Quarterly*, *27*(1), 1–22. https://doi.org/10.18352/lq.10185

Verma, V. K., & Charu. (2023). Research support services: an analysis of top science and technology institutions. *Library Philosophy and Practice*, 1–26. https://digitalcommons.unl.edu/libphilprac/7602/

Voß, V., & Hamrin, G. (2018). Establishing RDM services for small-scale data producers at big universities. *LIBER Quarterly: The Journal of the Association of European Research Libraries*, *28*(1), 1–58. https://doi.org/10.18352/lq.10255

Wang, M., & Fong, B. L. (2015). Embedded data librarianship: a case study of providing data management support for a science department. *Science and Technology Libraries*, *34*(3), 228–240. https://doi.org/10.1080/0194262X.2015.1085348

Weaver, L. (2017). *The collaboration spectrum revisited*. Tamarack Institute. Retrieved from https://www.tamarackcommunity.ca/hubfs/Resources/Publications/Collaboration%20Spectrum%20Revisited_Liz%20Weaver.pdf

Whitehead, M., Askey, D., Bourne-Tyson, D., Karen Estlund, S. H., Stewart, C., Tancheva, K., Walters, T., Muilenburg, J., & Ruttenberg, J. (2021). *ARL/CARL joint task force on research data services: Final report*. ARL/CARL. https://doi.org/10.29242/report.arlcarlrdstaskforce2021

Whitmire, A. L. (2015). Implementing a graduate-level research data management course: Approach, outcomes, and lessons learned. *Journal of Librarianship & Scholarly Communication*, *3*(2), 1–22. https://doi.org/10.7710/2162-3309.1246

Whyte, A., & Tedds, J. (2011). *Making the case for research data management* (DCC Briefing Paper). Digital Curation Centre. Retrieved from https://www.dcc.ac.uk/sites/default/files/documents/publications/Making%20the%20case.pdf

Wilms, K. L., Stieglitz, S., Ross, B., & Meske, C. (2020). A value-based perspective on supporting and hindering factors for research data management. *International Journal of Information Management*, *54*, 102174. https://doi.org/10.1016/j.ijinfomgt.2020.102174

Wilson, J. A. J., & Jefferys, P. W. (2013). Towards a unified university infrastructure: The data management roll-out at the university of oxford. *International Journal of Digital Curation*, *8*(2), 235–246. https://doi.org/10.2218/ijdc.v8i2.287

Witt, M. (2012). Co-designing, co-developing, and co-implementing an institutional data repository service. *Journal of Library Administration*, *52*(2), 172–188. https://doi.org/10.1080/01930826.2012.655607

Wittenberg, J., & Elings, M. (2017). Building a research data management service at the University of California, Berkeley: A tale of collaboration. *IFLA Journal*, *43*(1), 89–97. https://doi.org/10.1177/0340035216686982

Woods, H. B., & Pinfield, S. (2021). Incentivising research data sharing: A scoping review. *Wellcome Open Research*, *6*, 355. https://doi.org/10.12688/wellcomeopenres.17286.2

Xiao, S., Ng, T. Y., & Yang, T. T. (2022). Research data stewardship at the University of Hong Kong. *Library Management*, *43*(1–2), 128–147. https://doi.org/10.1108/LM-09-2021-0079

Yee, M., Surkis, A., Lamb, I., & Contaxis, N. (2023). The NYU Data Catalog: A modular, flexible infrastructure for data discovery. *Journal of the American Medical Informatics Association*, *30*(10), 1693–1700. https://doi.org/10.1093/jamia/ocad125

Yoon, A., & Donaldson, D. R. (2019). Library capacity for data curation services: A US national survey. *Library Hi Tech*, *37*(4), 811–828. https://doi.org/10.1108/LHT-12-2018-0209

Yoon, A., & Schultz, T. (2017). Research Data Management services in academic libraries in the US: A content analysis of libraries' websites. *College & Research Libraries*, *78*(7), 920–933.

Yu, H. H. (2017). The role of academic libraries in Research Data Service (RDS) provision opportunities and challenges. *Electronic Library*, *35*(4), 783–797. https://doi.org/10.1108/EL-10-2016-0233

Yu, F., Deuble, R., & Morgan, H. (2017). Designing research data management services based on the research lifecycle—A consultative leadership approach. *Journal of the Australian Library*

and Information Association, *66*(3), 287–298. https://doi.org/10.1080/24750158.2017.1364835

Zorich, D. M., Waibel, G., & Erway, R. (2008). *Beyond the silos of the LAMs: Collaboration among libraries, archives, and museums*. OCLC Research. Retrieved from https://www.oclc.org/content/dam/research/publications/library/2008/2008-05.pdf

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Ho, R. C. Y., Wong, S. N., Chia, P., Tang, C., & Ng, M. T. T. (2025). Research data management services in academic libraries to support the research data life cycle: A systematic review. *Journal of the Association for Information Science and Technology*, 1–29. https://doi.org/10.1002/asi.70008