



Investigation of Research Data Maturity in Academic Libraries of Developed Countries

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ABSTRACT

A major development in academic libraries has been their recognition of the need to support research data services (RDS) to advance knowledge and science, augment novel solutions to social and economic impediments, and amplify immense potentials for competitiveness, productivity, and livability. This study investigated research data service maturity in academic libraries of developed countries with the intent to provide valuable insights and implications for other academic libraries. The maturity model informed the study. The study used in-depth web analysis and literature review to examine research data services in top-rated 100 university libraries of developed countries. Study findings showed a clear and well-developed landscape of research data services in these academic libraries; 81 (94%) of the investigated universities offered a wide array of both informational and technical services. The most common services consisted research data curation and storage service 81 (94%), research data management and training service 81 (94%), research data management reference service 80 (93%), research data introduction service 80 (93%) and data management plan and guidance 79 (92%) respectively. The least common service was the resource recommendation service 64 (74%). Study findings, therefore, suggest that the current services are extensive, robust and mature, signifying an overall maturity of the RDS landscape in academic libraries of developed countries.

CCS CONCEPTS

• Information systems; • Data management systems;

KEYWORDS

Research data management, academic libraries, developed Countries

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1 INTRODUCTION

RDS has become an essential service in academic libraries in the past decade, predominantly in industrialised countries. The paradigm shifts in scientific research supported by cyberinfrastructures, funder mandates for research data sharing and reuse, and the proactive role of libraries in shaping scholarly communication have occasioned this service. Furthermore, data deluge has raised concerns over how these valuable data volumes can be captured, curated, preserved and made available for discovery, sharing, and reuse. In this regard, the libraries have continuously assembled capabilities in the form of policies, knowledge, skills and training, technology and infrastructure, and collaborative partnerships to ensure efficient managing and delivery of research data services [11].

Although most academic libraries in the developed world have adopted these services with privity to their possible role and impact, not all are on the same level of maturity owing to contrasting views and service prerequisites at institutional, national and international levels differing on guidelines and capacity [19]. For instance, findings from studies, including [1]; [14] showed that the services, mainly information data services, were nearing maturity while others, such as [2]; [16] noted that the services were non-uniform and uneven in development.

Nonetheless, this is a rapidly changing landscape in demand of continuous studying. Additionally, examining landscapes of research data services in academic libraries is opportune and momentous for both academic libraries on the front-line and those already advanced [7]. Consequently, this calls for further studies to assess comparisons with proceeding surveys, evaluate trends along with relative maturity levels over time. This study reports the results of a major international survey of RDS in academic libraries of developed countries.

2 LITERATURE REVIEW

Academic libraries' involvement in RDS has been discussed in previous studies over the last decade. For instance, initial contributions by

[8] laid the case for academic libraries' involvement. Present studies, such as [4]; [10], discussed the development of these services and the potential roles of academic libraries, while [3]; [13] addressed the various prospects for academic libraries in RDS and the challenges, such as the development of capabilities and researchers' unwillingness to share data. The studies further identified researchers as generally ignorant of research data management practices, activities and benefits and, thus, proposed an urgent need for research data services [7]. Additionally, the Association of College and Research Libraries (ACRL) research planning and review committee (issues yearly peak trends and subjects affecting university libraries worldwide) and the International Federation of Library Associations and Institutions (IFLA) (champions for the welfare of library users globally) reports of 2019 and 2020 respectively emphasised the best practices and significance of RDS in academic libraries.

Notably, research data services in academic libraries are critical because: first, they are the basis of knowledge, discoveries, and novelties that propel present and future economic growth. Second, they promote research's impact through open scientific inquiry, save research time by making data readily available, grow networks through corroborative partnerships, and ensure accountability and reliable verification of research findings [17]. Third, they build scholarship, inform action and policy as new knowledge builds from discoveries, innovations, and open scientific inquiry. Lastly, [18] enlightens that research data services reduces the costs of researching by making research data readily available while limiting its duplication and acting as a way of meeting funder mandates.

A critical review of RDS maturity trends among academic libraries in developed countries shows that RDS implementation has gained momentum steadily. The heightened interest has been augmented by the need for long-term curation and preservation to avail research data for discovery, sharing and reusing. Accordingly, [1] report that prevalent RDS implementation has been evident in most industrialised countries' academic libraries. The implementation prevalence in select developed countries comprises: the United Kingdom 100%, Germany 100%, Canada 94%, Australia 86%, Ireland 71%, and the Netherlands 71%. The libraries have prioritised RDS, thus, developing capabilities in the form of policies, knowledge, skills and training, technology and infrastructure, and collaborative partnerships both internally and externally to create an RDS package that superiorly addresses researcher needs [14]. [15] confirm that RDS implementation has progressively become apparent. This present study follows on the quantitative works of [1]; [12]; [17] to examine RDS maturity in university libraries of the top 100 institutions of higher learning as enumerated by the US News and World Report 2021.

2.1 Maturity Model.

The maturity model has previously been used to demonstrate the development of research data services overtime [1]. Maturity in this perspective refers to the impression that as research data services extend to a full degree of fruition, they are regarded as wholly developed or mature.

According to [1], the maturity model can help inform analysis of a developing area such as the implementation process of research data services, as examined over a certain period. Maturity models

show the likely emergence of mature landscapes over time. Services that are not present are considered immature, indicating an overall immaturity landscape. Services that are present are deemed mature, meaning an overall maturity landscape.

In accordance with [9], the maturity model exemplifies library reactions to principal factors geared towards "scheduling," in relation to the timeframe within which research data services ought to be developed. "Organizational" in relation to capacity development in research data service roles, expertise, stewardship, structures, advocacy etc. "Legal" in relation to the legal requirements for capture and management of research data services "Economic" in relation to financial availability to support research data services, "Technological" in relation to technical competencies, technological support and leadership, etc. [9] as indicated in figure 1.

The present study adopts the model to explain the developments of research data services in academic libraries of the top 100 institutions of higher learning as enumerated by the USA News and World report 2020. The maturity model has also been used by [1] to explain RDS maturity in academic libraries. Additionally, [5] employed the model to explain scientific data management in academic libraries.

3 METHODOLOGY

The study utilized in depth web analysis and literature review to examine research data services in academic libraries of developed countries' top 100 Universities. First, the researcher analyzed each of the selected academic libraries' web pages, to ascertain the presence of research data services. If present, the study explored the pages further to gain exhaustive information regarding the services including their contents and forms. Additionally, the study executed a general search on google and scholarly databases for materials and references to the research data services in the examined academic libraries.

3.1 Participants

The study sampled university libraries of the top 100 institutions of higher learning as enumerated by the USA News and World report 2020. The USA News and World report is a multi-platform publisher of news and information, which includes authoritative ranking of the best 1,250 Universities. Institutions are ranked based on 13 indicators that measure their academic research performance and global and regional reputations. The rankings are powered by clarivate analytics.

Of the 100 Institutions, 14 were eliminated due to language barrier: These were:

1. Universite Paris Saclay (ComUE)
2. École Polytechnique Federale of Lausanne
3. University of Munich
4. Karolinska Institute
5. Universite Sorbonne Paris Cite-USPC (ComUE)
6. University of Tokyo
7. Vanderbilt University
8. King Abdulaziz University
9. Technical University of Munich
10. PSL Research University Paris (ComUE)
11. VU University Amsterdam
12. Humboldt-Universität zu Berlin

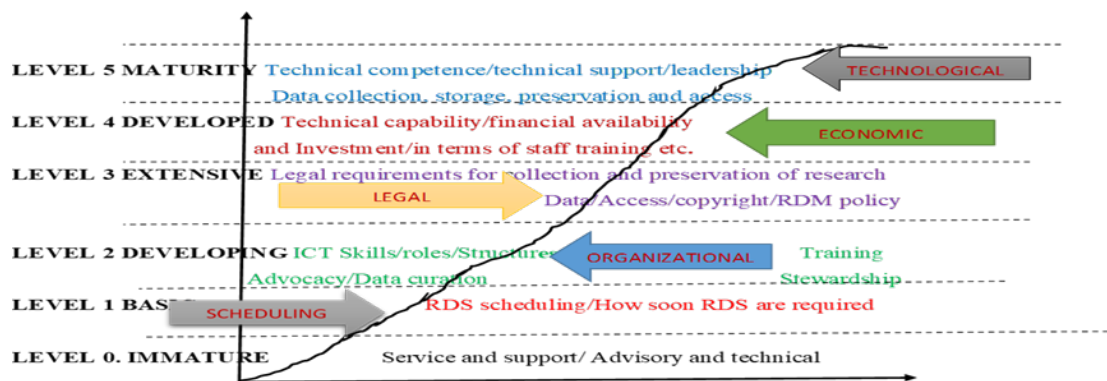


Figure 1: The Maturity Model [1]

Table 1: Table of distribution of RDS in Academic Library per Country

Country	Number of Universities offering RDS	Percentage of Universities offering RDS
Switzerland	1	1.23
Australia	7	8.64
USA	46	56.79
Denmark	1	1.23
Norway	1	1.23
United Kingdom	10	12.35
Belgium	1	1.23
Canada	2	2.47
Netherlands	6	7.41
Singapore	2	2.47
Sweden	1	1.23
Germany	1	1.23
China	2	2.47
Total	81	100%

13. Ghent University
14. University of Helsinki

Additionally, a quick review of the 86 academic libraries revealed that 84 (98%) were from developed countries and 2 (2%) (Tsinghua University and Peking University) were from China, an upper middle developing economy [6]. Although the [6] quotes China as an upper middle developing economy, its massive GDP and continued scholarship growth has put it in the same footing as the renown Industrialized countries. The choice of countries was also partly driven by the desire to facilitate comparisons with earlier surveys and to gauge the development of the services in diverse spheres. Consequently, a total of 86 academic libraries were examined.

4 DATA COLLECTION

Data capture was conducted between October to November 2021. Though web visits proffer a concrete and clear picture of the available services; the technique has its own limitations. For instance, only those services that appear on the library's Webpages are ascertained. Some services do not appear on the webpage. Such services

usually go unnoticed. Library webpages are also known to provide only a snapshot of the services being offered as libraries may be implementing or planning to implement other services. Password protected services are also not accessed. To address these shortcomings another comprehensive survey that would engross library service personnel is recommended

5 DISCUSSION OF FINDINGS

5.1 Summary of research data services in the University libraries

To permit a cross-sectional comparison of the research data services and understand the magnitude of changes in participant academic libraries, the findings are submitted as numbers and percentages.

Among the 86 academic libraries investigated, 81(94%) were offering research data services, as shown in Table 1 and Table 2 below. The 81 university libraries have dedicated webpages to schematize and submit research data services. The university libraries are located in the countries shown in the table below.

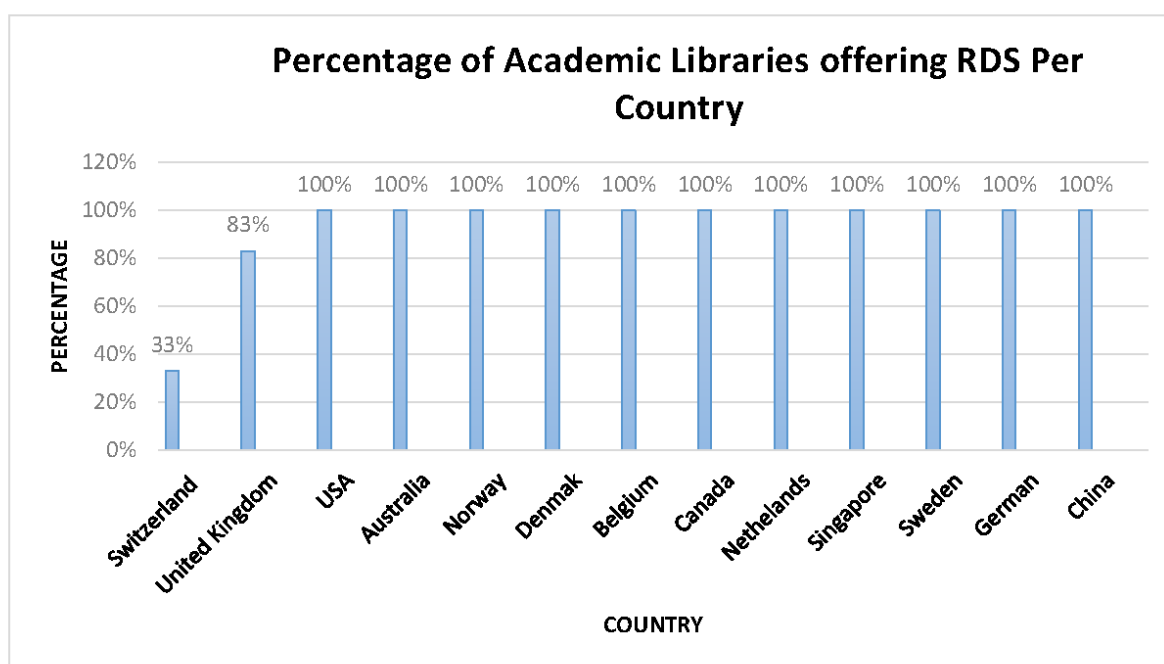


Figure 2: Figure of Academic libraries offering research data services per Country

In the United Kingdom, 10 out of 12 (83%) Academic libraries analyzed offer Research data services while 1 out of 3 (33%) in Switzerland have Research data services.

All the 46 (100%) Academic libraries examined in the US have established research data services. Similarly, all the Academic libraries analyzed in Australia 7 (100%), Denmark 1 (100%), Norway 1 (100%), Belgium 1 (100%), Canada 1 (100%), Netherlands 6 (100%), Singapore 2 (100%), Sweden 1 (100%), Germany 1 (100%) and China 2 (100%) have fully developed research data services. Figure 2 below shows the percentage of university libraries per country offering research data services.

Moreover, all the examined universities of the 86 academic libraries have a research division on their main webpages. This division is well developed and dedicated to research data services with a Vice Provost as the head. Additionally, the academic libraries in many Universities such as the University of Oxford, Yale University, University of California–Berkeley, and the University of Chicago, fall under the research division.

Among the 86 University Libraries examined, five do not offer research data services. However, the webpages of their mother institutions have the research division, fully dedicated to research data services. These Universities are:

- 1) University of Zurich
- 2) London School of Hygiene & Tropical Medicine
- 3) University of Geneva
- 4) University of Glasgow
- 5) University of Barcelona

Based on an overview of the services, the author found that these services could be divided into six aspects as shown in the table below:

- i. Research data introduction (Definition of research data, significance of management and sharing of research data);
- ii. Research Data management plan and guidance (how to develop a Data management plan (DMP), how to generate meta-data, how to manage, store, archive and preserve research data etc.);
- iii. Curation of research data and storage services (provision of research data storage services and the long term preservation);
- iv. Research Data management and training (Organization of instructional services/course trainings to researchers/users, offering workshops on essential skills for research data sharing and management);
- v. Research data management reference (provision of suggestions/ assistance when researchers/users experience difficulties); and
- vi. Resource recommendation (navigation of external datasets or repositories and associated resources).

Table 2 below shows the country, academic library and the 6 categorized Research Data Services offered

From the analysis, it can be established that the most common services were informational (Research data introduction, Data management plan and guidance (DMP), Research Data management and training, Research data management reference, Resource recommendation) as compared to technical data services (Curation

Table 2: Table of Country, University Library and the categorized Research Data Services offered

	Country	University Libraries	Research Data Introduction	Research data management plan and guidance	Research Data curation and Storage Services	Research data management and Training	Research Data Management References	Resource recommendations	Total RDS offered per University
1.	USA	Harvard University Libraries	*	*	*	*	*	*	6
2.	USA	MIT Libraries	*	*	*	*	*	*	6
3.	USA	Stanford University Libraries	*	*	*	*	*	*	6
4.	USA	University of California Berkeley Libraries	*	*	*	*	*	*	6
5.	United Kingdom	University of Oxford Libraries	*	*	*	*	*	*	6
6.	USA	Caltech Libraries	*	*	*	*	*	*	6
7.	United Kingdom	University of Cambridge libraries	*	*	*	*	*	*	6
8.	USA	Columbia University Libraries	*	*	*	*	*	*	6
9.	USA	Princeton University Libraries	*	*	*	*	*	*	6
10.	USA	University of Washington Libraries	*	*	*	*	*	*	6
11.	USA	Yale University Library	*	*	*	*	*	*	6
12.	USA	Johns Hopkins University-Sheridan Libraries	*	*	*	*	*	*	6
13.	USA	University of California-Los Angeles Libraries	*	*	*	*	*	*	6
14.	USA	University of Chicago Libraries	*	*	*	*	*	*	6
15.	USA	University of California-San Francisco	*	*	*	*	*	*	6
16.	USA	University of Pennsylvania	*	*	*	*	*	*	6
17.	USA	University of California-San Diego Libraries	*	*	*	*	*	*	6
18.	United Kingdom	Imperial College London Libraries	*	*	*	*	*	*	6
19.	USA	University of Michigan-Ann Arbor Libraries	*	*	*	*	*	*	6
20.	Canada	University of Toronto Libraries	*	*	*	*	*	*	6

21.	United Kingdom	University College London Libraries	*	*	*	*	*	*	6
22.	USA	Duke University Libraries	*	*	*	*	*	*	6
23.	USA	Cornell University Libraries	*	*	*	*	*	*	6
24.	USA	Northwestern University Libraries	*	*	*	*	*	*	6
25.	Switzerland	Swiss Federal Institute of Technology Zurich Library	*	*	*	*	*	*	5
26.	Australia	University of Melbourne Library	*	*	*	*	*	*	6
27.	United Kingdom	University of Edinburgh Library	*	*	*	*	*	*	6
28.	USA	New York University	*	*	*	*	*	*	6
29.	Canada	University of British Columbia Library	*	*	*	*	*	*	6
30.	Australia	University of Sydney Library	*	*	*	*	*	*	6
31.	USA	University of North Carolina–Chapel Hill Library	*	*	*	*	*	*	6
32.	USA	Washington University in St. Louis Library	*	*	*	*	*	*	6
33.	Denmark	University of Copenhagen Library	*	*	*	*	*	*	5
34.	USA	University of Wisconsin–Madison Libraries	*	*	*	*	*	*	6
35.	USA	University of Texas–Austin Libraries	*	*	*	*	*	*	6
36.	USA	University of California–Santa Barbara Library	*	*	*	*	*	*	6
37.	Singapore	National University of Singapore Libraries	*	*	*	*	*	*	6
38.	United Kingdom	King’s College London	*	*	*	*	*	*	6
39.	USA	University of Minnesota–Twin Cities	*	*	*	*	*	*	6
40.	Australia	University of Queensland Australia library	*	*	*	*	*	*	6
41.	USA	McGill University Library	*	*	*	*	*	*	6

42.	USA	University of Colorado–Boulder Libraries	*	*	*	*	*	*	6
43.	USA	University of Pittsburgh Libraries	*	*	*	*	*	*	6
44.	USA	Boston University Libraries	*	*	*	*	*	*	6
45.	USA	Ohio State University–Columbus Libraries	*	*	*	*	*	*	6
46.	Singapore	Nanyang Technological University Libraries	*	*	*	*	*	*	6
47.	China	Tsinghua University Libraries			*	*			2
48.	Netherlands	University of Amsterdam Libraries	*	*	*	*	*		5
49.	USA	University of Maryland–College Park Library	*	*	*	*	*		5
50.	Germany	Heidelberg University Library	*	*	*	*	*		5
51.	USA	University of Illinois–Urbana-Champaign Library	*	*	*	*	*	*	6
52.	Netherlands	Utrecht University Library	*	*	*	*	*	*	6
53.	Belgium	Catholic University of Leuven Libraries	*	*	*	*	*		5
54.	USA	University of California–Santa Cruz	*	*	*	*	*	*	6
55.	United Kingdom	University of Manchester Libraries	*	*	*	*	*	*	6
56.	USA	University of California–Davis	*	*	*	*	*	*	6
57.	Switzerland	University of Zurich							0
58.	Australia	Monash University Library	*	*	*	*	*	*	6
59.	USA	University of Southern California	*	*	*	*	*	*	6
60.	USA	Rockefeller University Library	*	*	*	*	*		5
61.	China	Peking University	*		*	*	*		4
62.	USA	Georgia Institute of Technology Library	*	*	*	*	*	*	6

63.	Australia	University of New South Wales Library	*	*	*	*	*	*	6
64.	Netherlands	Erasmus University Rotterdam	*	*	*	*	*	*	6
65.	Australia	A NU Library	*	*	*	*	*	*	6
66.	USA	Pennsylvania State University–Park Library	*	*	*	*	*	*	5
67.	USA	Emory University Library	*	*	*	*	*	*	5
68.	USA	Mount Sinai School of Medicine Library (Levi Library)	*	*	*	*	*	*	6
69.	United Kingdom	University of Bristol Library	*	*	*	*	*	*	5
70.	United Kingdom	London School of Hygiene & Tropical Medicine							0
71.	USA	University of California–Irvine	*	*	*	*	*	*	6
72.	USA	Carnegie Mellon University	*	*	*	*	*	*	6
73.	USA	University of Arizona	*	*	*	*	*	*	5
74.	Australia	University of Western Australia	*	*	*	*	*	*	6
75.	Netherlands	Wageningen University and Research Center Library	*	*	*	*	*	*	6
76.	Netherlands	Leiden University Library	*	*	*	*	*	*	5
77.	Sweden	Lund University Library	*	*	*	*	*	*	5
78.	Switzerland	University of Geneva Library							0
79.	USA	Michigan State University Library	*	*	*	*	*	*	5
80.	United Kingdom	University of Southampton Libraries	*	*	*	*	*	*	6
81.	United Kingdom	University of Glasgow Library							0
82.	Spain	University of Barcelona Library							0
83.	United Kingdom	University of Birmingham Library	*	*	*	*	*	*	6
84.	Norway	University of Oslo Library	*	*	*	*	*	*	5
85.	USA	Brown University Library	*	*	*	*	*	*	5

86.	Netherlands	Radboud University Nijmegen	*	*	*	*	*	*	6
Total			80	79	81	81	80	64	464

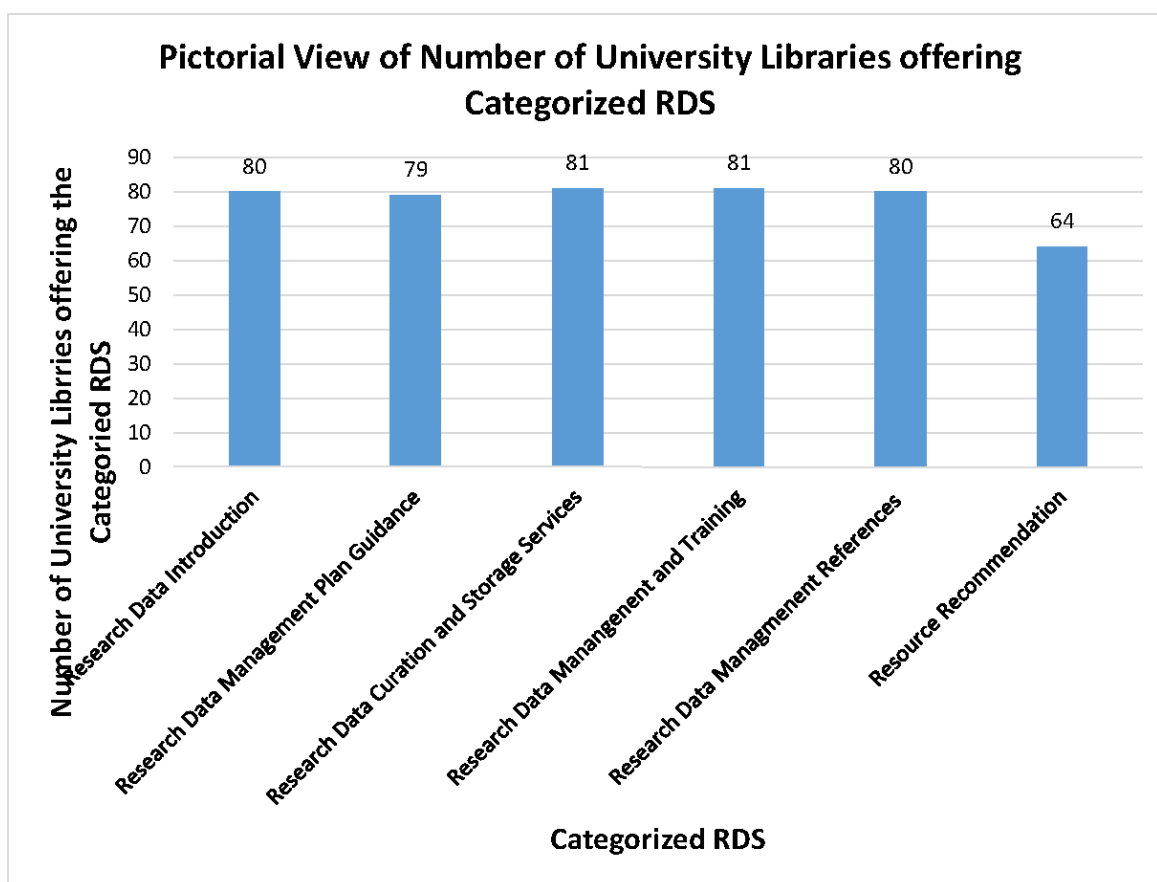


Figure 3: Figure of each categorized Research Data Services and the number of University Libraries offering them

of research data and storage services). The findings are in tandem with, [1]; [15] who also established that academic libraries were offering more information/advisory services as compared to technical services. Figure 3 below shows a pictorial view of each service and the number of academic libraries offering them

6 ANALYSIS OF EACH OF THE 6 CATEGORIZED RESEARCH DATA SERVICES

6.1 Research data introduction

As shown in table 2 and Figure 3 above, 80 out of 86 (93 %) academic libraries offer the research data introduction service; the second most prevalent of the six categorized services. This finding denotes the significance of the research data introduction service in delivery of research data services. The service involves elucidating to users what research data is and the significance of managing, sharing

and preserving the research data. For instance, the research data management section of the library at the University College London defines research data as original sources or material created or collated by the researcher for purposes of conducting a research project. It gives examples of research data as notebooks, field notebooks, primary research data (including research data in hardcopy or in computer readable form), questionnaires, audiotapes, videotapes, models, photographs, etc. The library further lists advantages of managing preserving, sharing and reusing data to include improved visibility and citation and helping researchers comply with legal, ethical, institutional and funder mandates. Additionally, the Cornell University Library, Leeds University Library and the Cambridge University Library, have a glossary for research data services, elucidating terms such as “research data”, “digital curation” “data citation” data management plan “metadata description” etc.

6.2 Data management plan and guidance (DMP)

Research funders are increasingly requiring researchers to draw up a Data Management Plan (DMP) as a necessary condition for funding. A Data Management Plan guides researchers reflect on how they will generate, analyze and share data during the research process and afterwards. Consequently, information on drawing up DMPs that meet funder requirements is a popular content item for academic libraries.

Study findings revealed that of the 86 University Libraries investigated, 79 (92%) or 79 out of the 81 (98%) offering research data services guide their users in developing a data management plan. In most academic libraries investigated, the content list of a data management plan generally contains an introductory, recommended items of a DMP, creation or documentation of metadata, requirements for funding and tools or templates for making DMPs. For instance, all the 79 (100%) academic libraries investigated had an introductory to a DMP including what it is about, why a DMP is vital and how to draw up a DMP. Additionally, 76 out of the 79 (96 %) academic libraries with a DMP service clearly listed the standards for funding as provided by key grant bodies. To assist users and faculty draw a DMP compliant with funder body requirements, 77 of the 79 (97 %) academic libraries offer checklists that ought to be put into consideration when developing a DMP. For instance, the University of Edinburgh Library, the University of Copenhagen library, the Stanford University Libraries and the University of Manchester Libraries enumerated the fundamental content to be included in a DMP as follows:

- **Templates** (based on different funder requirements)
- **Data Collection** (What data the researcher will collect or create, how the data will be collected or created)
- **Documentation and Metadata** (What documentation and metadata will accompany the data)
- **Ethics and Legal Compliance** (How the ethical, copyright and Intellectual Property Rights will be managed)
- **Storage and Backup** (How the data will be stored and backed up during the research and how the researcher will manage access and security)
- **Selection and Preservation** (the data that is of long-term value and should be retained, shared, and/or preserved.)
- **Data Sharing** (How the data will be shared, restrictions of data sharing if any)
- **Responsibilities and Resources** (Person, organization responsible for data management, the resources required for the project etc.)

Furthermore, to abridge the process of developing a DMP, the libraries provide DMP tools or templates to their users. The most often recommended tools are DMP Online and DMP Tool both intended to offer a schemed setting for DMPs with direct linking to funder mandates. For instance, the Australian National University Library has a default DMP Tool template that it recommends to its users with a step by step guidance to development of a new DMP tool online, direct linking to funders, options to include/exclude funders etc.

Almost all DMPs recommended the inclusion of metadata to be utilized. Metadata usually describe the contents of datasets and facilitate their retrieval and utilization. In this investigation, 74 of

the 79 (94%) libraries offering the DMP made available metadata information, including the significance of metadata, how to generate metadata etc. Table 3 below shows the Digital Curation Center's Check-list for a DMP.

Figure 4 below shows the common DMP items among the University Libraries offering the DMP service

6.3 Research Data curation and Storage Service

Academic libraries offer data curation and storage services for purposes of long term access, sharing and reuse of research data. Of the 86 academic libraries investigated, 81 offer the services (94.12%) or all the libraries that offer research data services offer the service. According to the study findings, most of the storage and data curation services were developed on the basis of institutional repositories with the help from ICT personnel. For example, the University of Washington uses Dspace to establish the "Research works Archive", that collects intellectual/scholarly output generated by its community. The repository's interface offers an easy self-archiving system, and organizes the resources in a logical, and effortlessly retrievable fashion.

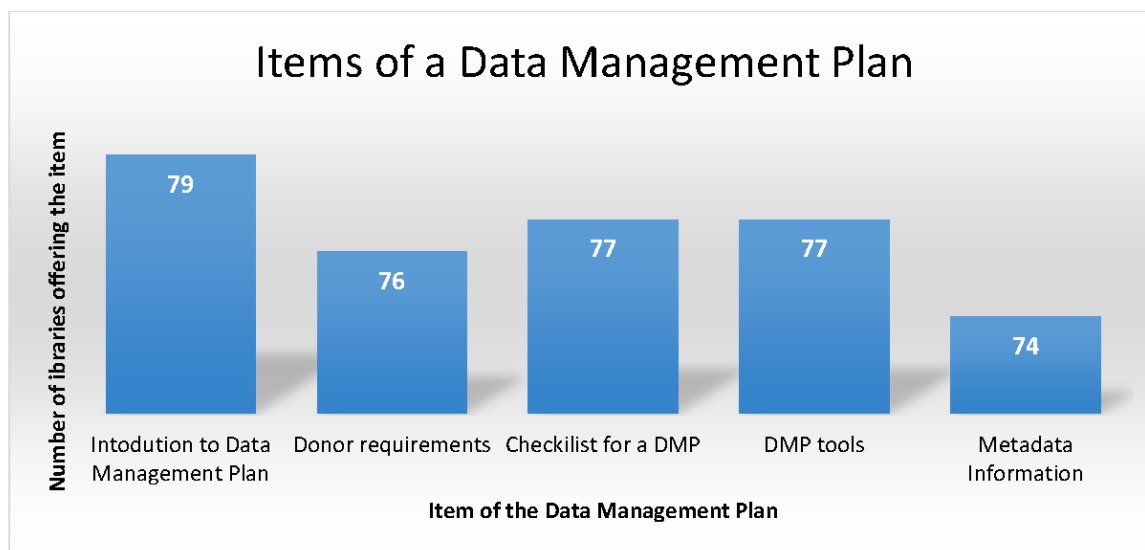
However other Academic libraries developed expert digital repositories for users to preserve and manage their data. The Eli Scholar is a secure, sustainable digital platform for the scholarly output of researchers at Yale University. It promotes preservation, management, sharing, discovery and access of research data. Kings Research Data Management System, a digital repository at Kings College London Library offers long term storage and access to datasets that support published research and/or have long term value. The digital repository promotes preservation, management, sharing, and makes the data discoverable allowing the scholarly community to reuse the data.

6.4 Research Data Management Training

Studies have overtime reported that researchers do not have the necessary skills to manage their research data during and after the research process. A number of Academic libraries have started equipping researchers with the needed skills to cope with these challenges. Study findings show that of the 86 libraries investigated, 81 (94.2%) offer research data management training services or all the libraries that offer RDS offer the service. The services are mainly offered in the form of workshops, online courses, lectures and tutorials. For instance, the University of Manchester Library, offers a comprehensive research development programme dubbed "My research essentials". MRE includes workshops, information sessions, and online resources designed to support development for researchers at all career stages. Topics covered include resources to use during the research process, dissemination of research and raising individual research profile. Another University Library, the University of Western Australia Library offers induction and consultation sessions, workshops and seminars and self-help guides on research data management to support the research activities of its researchers while the libraries of Northwestern University Libraries, Kings College London Library, University of Arizona Libraries, University of British Columbia Libraries, University of Manchester Libraries etc. have made available downloadable training brochures on their webpages to help researchers choose the

Table 3: Digital Curation Center’s Check-list for a Data Management Plan

Checklist	Guidance
Introductory	Lays out the project and the plan, the envisioned audiences, the internal as well as external policies
Data description	Defines the data types, forms, documentation, metadata, capture as well as creation
Ethics and legal compliance	Addresses the subjects surrounding ethical issues, intellectual property subjects and privacy
Selection and preservation	Concerns the data to be retained or preserved
Storage and back up (Short term)	Focusses on specifics regarding management of data throughout the project lifespan
Storage and back up (long term)	Concentrates on preservation, selection, appraisal, discovery ,as well as access of research data
Data sharing	Outlines how the potential users will find and use the data, the access controls/restrictions, when the data will be made available, method to be used in data sharing and possible acknowledgment by third party
Responsibilities and resources	Persons responsible for implementing DMP, data management activities, data ownership subjects, data capture, metadata production, data quality, storage and backup, data archiving & data sharing. Consider who will be responsible for ensuring relevant policies will be respected Resources in terms of expertize required, hardware, software, charges applied,
Adherence, review and security	Observance to the plan, funder requirements, reviews to ensure on going aptness , access and security arrangements
Annexes	Capture any necessary subjects for inclusion/exclusion

**Figure 4: Figure of the DMP service and the common items in the University Libraries**

skills they want to develop and the courses that might be more suitable for them

6.5 Research Data Management References

Researchers unavoidably encounter innumerable challenges throughout the research process. Consequently, offering researchers data management reference services is pivotal. Study

findings showed that 80 out of the 86 (93.02%) Academic libraries offer data management reference services. The libraries provide real time embedded consultation windows where researchers can promptly chat Data reference personnel. The libraries also provide contact details mostly email and phone numbers on the webpages for researchers to consult the Data reference personnel. For instance, the Research data support service (RDSS) at Yale University Library is an excellent first stop for researchers' questions. RDSS brings together specialists from around campus who offer consultancy services to researchers on their data management needs. Consultants answer questions on how to write data management plans, how to clean data, where to store data, etc. RDSS also maintains a webpage as a portal for research data support services. The webpage has well-designed real-time embedded consulting window, in which the user can instantly chat with reference librarians. Similarly, the MIT Library has put in place research data consultancy services where researchers can contact library personnel directly through a chat with us real time session or email.

6.6 Resource recommendation

Other than their research data services, several Academic libraries also recommend research materials, DMP tools and open digital repositories to their Researchers. In this survey, of the 86 Academic libraries investigated, 64 (74.42%) of the 86 or 64 of the 81 (79%) academic libraries offering research data services offer resource recommendation services. For instance, apart from making known to users its DMP tool, Yale University Library shares links to research data services of Inter University Consortium for Political and Social Research (ICPSR), Data ONE, the University of Wisconsin Madison, MIT Libraries and the California Digital Library for purposes of referencing. In addition, the Library makes available free research data training materials developed by the University of Edinburgh, the University of Minnesota Library and the Digital Curation Center (DCC).

Equally, The Cambridge University Library recommends that its users amass their data in the UK Data Archive or other data curation centers to advance sharing and reuse while The MIT Library, Columbia University Library and Duke University Library not only offer data management templates but also share links to templates developed by other Academic libraries.

Lastly, Princeton University Library amassed all online free digital repositories of the University of Minnesota Library, MIT Library and the University of North Carolina at Chapel Hill Library and made them available for discovery and access by subject.

6.7 RDS Maturity Model

The range of RDS activities explored in this survey was represented on a simple "landscape maturity model which reflects RDS developments over time. Study findings showed that RDS activities in academic libraries of developed countries are robust and advanced, representing a broad and comprehensive portfolio of fully developed and operational services. These services can, therefore, be deemed to have reached maturity. The research data maturity model depicts academic libraries of developed countries as having assembled the key drivers of RDS (scheduling, organisational, legal, economic, and technological).

7 CONCLUSIONS

Research data makes an essential and expensive output of the scholarly research process and acts as an indispensable part of the evidence necessary to evaluate research results and rebuild the events and processes leading to them. This study has revealed a clear and well-developed landscape of research data services in academic libraries in developed countries, with 81 (94.19%) of the investigated libraries offering the services. The scale and complexity of the services show that academic libraries in these countries offer a wide array of research data services: from informational to technical services and supporting the various stages of the research process. A substantive group of technical data services that were previously lacking are present. The most common services include research data curation and storage services, research data management and training services, research data management references, research introduction services and the data management plan and guidance, respectively. The least common service comprises the resource recommendation service.

In addition, librarians participate in research project teams with the libraries offering support services to users in the course of the research process. Evidently, a majority of library directors have recognised the importance of research data and established solutions that fit their institutional needs and priorities. Some libraries are advanced in offering and planning the services; hence, they have taken leading roles in the ongoing discussions. In this regard, the current services can be described as extensive, robust, and mature, signifying an overall maturity of the RDS landscape in the first world academic libraries.

The study limitations, such as the small sample size, which may not reflect the accurate picture of academic libraries in developed countries for the reason that only the top 100 libraries were analysed, might be addressed by further research, by widening the national and international coverage, as well as tracking changes continuously. Nevertheless, the international comparison of RDS development highlighted in this study and previous studies have clearly illustrated crucial RDS developments and issues over time. It has also evidenced increased maturity of both information and technical services as predicted by [1]; [17].

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