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Pro-Metrics

ORIGINAL ARTICLE

Diagnosis of research data management in teachers and researchers of the Universidad Central "Marta Abreu" de Las Villas

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ABSTRACT

Objective. This study aimed to diagnose the practices related to research data management (RDM) at the Universidad Central "Marta Abreu" de Las Villas, Cuba.

Design/Methodology/Approach. This study employed a nonexperimental, descriptive, and cross-sectional design. An online questionnaire was administered to teachers and researchers. The instrument consisted of 42 questions grouped into five dimensions.

Results. The sample consisted of 320 individuals, 4.06% of whom were researchers and 95.94% of whom were teachers. The majority of research was conducted within the fields of social sciences (45%), followed by natural sciences (20.94%) and engineering (19.69%). Over 60% of the data generated in the research were digital. Text documents (94.38%) and spreadsheets (55%) were the most commonly used data formats. The mean annual storage capacity was 44.06%, with a minimum of 50 GB. Personal computers, universal serial bus sticks, and other storage devices were the most common forms of data storage. In at least one instance, 54.69% of respondents indicated they had experienced data loss. A majority (69.06%) of respondents indicated that they would prefer the university to retain at least some of their data. Email was identified as the primary data exchange method (72.81%).

Conclusions. Best practices for managing research data were not followed, limiting their preservation, socialization, and impact. There was no institutional policy for managing these data. However, teachers and researchers expressed interest in developing a culture of RDM.

Keywords: research data management research data open science higher education.

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1. INTRODUCTION

Research data management (RDM) emerged in an environment where data were not typically published, shared, or reused. In the view of Pinfield *et al.* (2014), this situation gave rise to the necessity of developing policies, infrastructures, and services in scientific institutions to manage research data (RD). The endeavor aims to provide researchers with the requisite tools and resources to facilitate the creation, collection, manipulation, analysis, transport, storage, and preservation of datasets. We are witnessing a second significant transformation in scientific and technological development, driven by the exponential growth in data generated by scientific activities, particularly those in digital formats. Advances in the transmission of information have reached a speed commensurate with the volume produced and consumed in the present era, necessitating the automation and minimization of interference in its transit (Couto, 2016).

As defined by Tripathi *et al.* (2017), RDM encompasses all the activities and processes undertaken to ensure the proper documentation, organization, storage, archiving, and selection of RD to ensure their accessibility for use and reuse upon the conclusion of the research project. Conversely, Bryant, Lavoie, and Malpas (2017) posit that RDM has emerged as a significant area of interest in higher education, prompting substantial investment in services, resources, and infrastructure to support the data management needs of researchers. Furthermore, these authors indicate that RD is now recognized as a crucial research and scholarly communication element.

Alonso Arevalo (2019) notes that proper data management is critical to maximizing the utility and value of high-quality DI and, thus, research excellence. Data organization and archiving facilitate data sharing and ensure the long-term sustainability and accessibility of data, enabling reuse for future scientific endeavors. The advancement of RDM is a multifaceted process, necessitating the involvement of researchers and professionals tasked with ensuring the preservation and accessibility of data. Nevertheless, some Australian, European, and American universities have initiated the process, with similar institutions in Canada and a few in Latin American countries following suit. There are currently no documented instances of RDM in Cuban universities. This study, which is part of an ongoing doctoral research project and responds to the international initiative "Research Data Management Strategy in the Latin American Context (RDMS-LatAm)," sponsored by VLIR-UOS, aims to diagnose the state of DMS at the Universidad Central "Marta Abreu" de Las Villas (UCLV).

2. MATERIALS AND METHODS

A nonexperimental, descriptive, cross-sectional study was developed, in which an online questionnaire was applied to a sample of professors and researchers affiliated with UCLV, given their fundamental role as creators and consumers of RD. This approach has been previously employed in research (Elsayed & Saleh, 2018; Krahe *et al.,* 2024). The number of subjects included in the study was calculated based on the population of full-time faculty and researchers at the institution, with a heterogeneity of 50%, a margin of error of 5%, and a confidence level of 95%. This resulted in a sample size of 320 individuals.

The questionnaire used was an adaptation of the one developed and applied at the University of Hasselt (Belgium) during a study similar to the present one (Vancauwenbergh *et al.,* 2018). The adaptation was based on a translation into the Spanish language, considering the appropriate and contextualized use of the different terms. It consisted of 42 questions grouped into five dimensions:

1. data types and formats
2. storage, archiving, backup, and loss of data
3. ethical and legal aspects
4. infrastructure and services
5. accessibility and reusability

The FOS 2017 classification (European Commission, 2019) was employed to ascertain the specific scientific disciplines to which each individual included in the sample can be attributed.

3. RESULTS

The population comprised 320 individuals affiliated with the 12 faculties and two research centers of the UCLV. Of those, 4.06% (13) were

researchers, and 95.94% (307) were professors. Among the teachers surveyed, there was a greater representation of those holding the teaching category of assistant professor (29.38%), followed by tenured (27.81%) and assistant (22.82%). Among the researchers, the predominant group comprised tenured and associate professors, each representing 38.46% of the total, followed by assistants, who constituted 23.08% of the group. A total of 31.88% of the subjects had the category of doctor of science, while 20.63% were in the doctoral training phase.

Figure 1 depicts the distribution of the population of teachers and researchers according to the areas of knowledge in which they work. It reveals a predominance of social sciences (CS) at 45%, followed by natural sciences (20.94%) and engineering (19.69%).

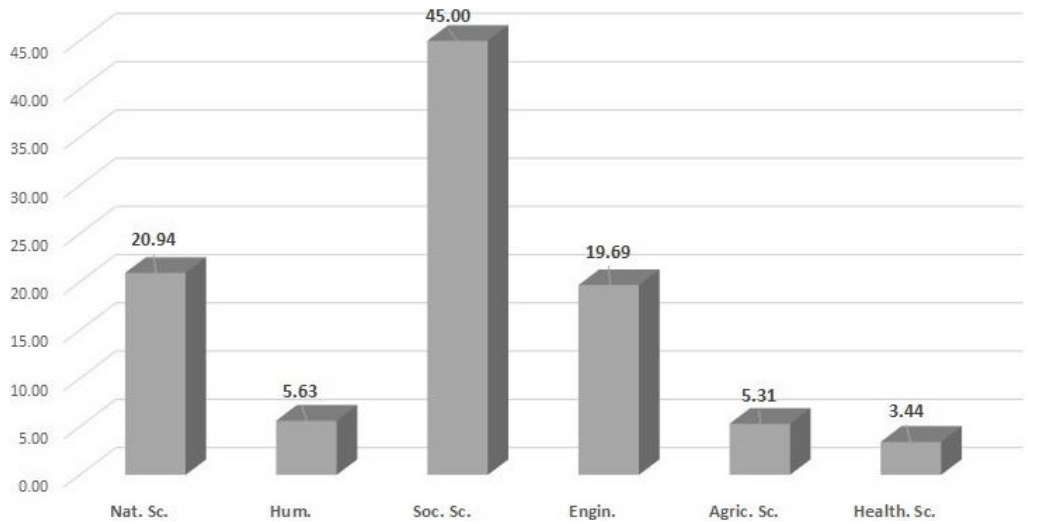

Figure 1. Distribution of the population of teachers and researchers surveyed at the UCLV according to their areas of expertise. **Notes:** Percentage calculated based on total respondents. Nat. Sc.: natural sciences; Hum.: humanities; Agric. Sc.: agricultural sciences; Soc. Sc.: social sciences; Engin.: engineering sciences; Health Sc.: health sciences.

3.1. Dimension 1: Data types and formats

The primary source for obtaining RD was the data generated by the researchers themselves in their research (75.31%), followed by publicly available data in an open manner (56.25%) and secondary data provided by public organizations (27.81%). A strikingly similar utilization of both qualitative (84.69%) and quantitative (83.44%) RD was observed. A total of 55.94% of respondents indicated that they had utilized previously processed RD, while 36.88% reported employing primary data, and only 6.56% indicated the use of clinical RD. Regarding the volume of digital data generated during the investigations, 65.31% of respondents indicated that the volume was greater than 60%. The most frequently used data format was the text document (94.38%), followed by spreadsheets (55%). Figure 2 illustrates the frequency of use of the various data formats in the sample under study.

63.44% of respondents indicated that they had documented their RD sets following the data management rules specified by the research unit. Conversely, 69.06% of respondents indicated utilizing some metadata standard for documenting their datasets. In the total sample, 50.31% of respondents indicated that they store and work with multiple versions of the same dataset. Concerning data management plans (DMP), 30.94% indicated that they are always performed, 25% when requested, 18.75% only sometimes, 14.38% never, and 10.94% rarely. 35.94% of respondents reported using templates for DMP (provided by the research unit and institution). Of the remaining respondents, 31.56% indicated that they rarely use templates for DMP, 28.44% have never done so, 3.44% reported using templates for DMP provided by the funding entity, and only 0.63% indicated that they used the *DMPonline* tool.

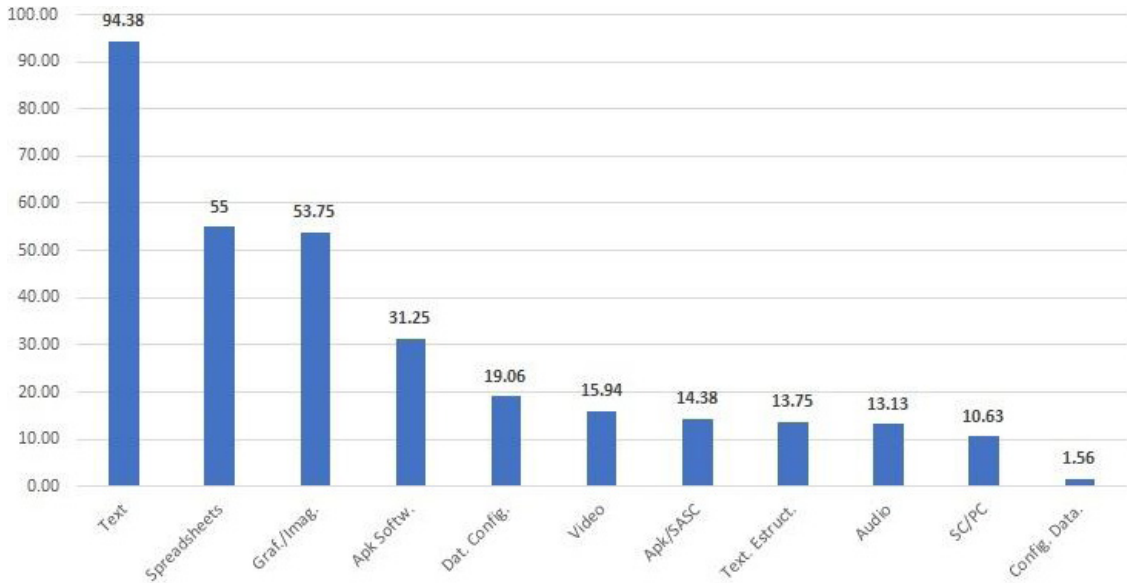

Figure 2. Percentage of use of the different research data formats. **Notes:** Text: text documents (doc, odf, pdf, txt, etc.); Spreadsheets (XLS, ODS, CSV, SAS, Stata, SPSS, etc.); Graf./Imag.: graphics/images (JPEG, SVG, PNG, GIF, TIFF, etc.); Apk/SASC: software applications source code (CSS, JavaScript, Java, etc.); DB: databases (MS Access, MySql, Oracle, etc.); Video: videos (MPEG, AVI, QMV, MP4, etc.); Text. Struct.: structured text (HTML, JSON, TEX, XML, etc.); Audio: audio (MP3, QAV, AIFF, OGG, etc.); SC/PC: source code/program code; Config. Data: configuration data (INI, CONF, etc.).

3.2. Dimension 2: Storage, archiving, backup, and loss of data

Table 1 illustrates the mean volume of RD that subjects store annually. The data indicate that the majority of stored data was in small volumes.

Research data volume	No.	% TM
<50 MB	141	44.06
50-100 GB	88	27.5
100 GB to 1 TB	34	10.63
1 TB to 1 PB	5	1.56
I am not sure	52	16.25

Notes: MB: megabytes; GB: gigabytes; TB: terabytes; PB: petabytes; % TM: percentage with respect to the total sample; No.: number of respondents selecting each volume of data.

Table 1. The volume of RD is stored on average annually by the researchers and teachers included in the sample.

A total of 1.88% of respondents indicated that they utilized their personal computers (laptops or desktops) and storage devices as the primary units for storing their RD. Additionally, 28.75% of respondents stored their RD on institutional servers, while 30.63% also employed cloud storage services, such as the one available at UCLV, for this purpose. A total of 36.25% of population indicated that they stored their RD exclusively on their personal computers and other storage devices under their ownership. A total of 105 respondents (32.81%) indicated that they had encountered challenges in storing their RD due to insufficient storage space. Of these individuals, 92.38% addressed this issue by acquiring a new storage device. A total of 11.88% of respondents indicated that they did not have a backup copy of their RD, while 45.94% had created a backup of only a portion of their data, and 44.38% had a complete backup copy of all their data.

80% of respondents indicated they primarily utilize personal computers for backup purposes. Additionally, 50% of respondents reported using external devices, such as universal serial bus (USB) sticks and external disks, for this purpose. Furthermore, 26.25% of respondents indicated that they utilize UCLV's own cloud service for backup, while 24.06% reported using the institution's servers for this purpose. Finally, 18.44% of respondents indicated keeping copies of their data on paper. A total of 54.69%

of respondents indicated that they had experienced the loss of their RD at some point. A total of 58.44% of respondents indicated that they always take measures to ensure the security of physical data, network security, or computer systems and files. In contrast, 34.69% reported taking such measures sometimes, and 5.94% indicated they never do so.

The deposition of RD in research data repositories (RDR) was minimal, with only 1.56% of respondents indicating utilization of such platforms. Following the conclusion of their respective projects, 73.44% of the sample population reported retaining their RD. The remaining 25% stored their data within the research unit, specifically at the faculty, department, or center level. Notably, 1.56% of respondents needed to retain their data following the completion of their projects.

3.3. Dimension 3: Ethical and legal issues

A total of 69.06% of respondents indicated that, at a minimum, some of their RD should be retained by the university for its own use or that of third parties. About the degree of processing applied to RD obtained from external sources, 94.06% have engaged in some form of processing, encompassing activities such as cleaning and compilation (48.13%) and more sophisticated operations (34.06%). Another factor related to the utilization of external RD pertains to the degree of anonymization of the source from which they are derived. The findings indicate that 43.44% of respondents asserted that external RD is never anonymized, 32.81% stated that they are occasionally anonymized, and 15.31% indicated that they are predominantly anonymized.

The management of RD may rise legal concerns. In this regard, 7.5% of respondents indicated they had presented them frequently, 45.31% sometimes, and 41.88% never. In relation to the degree of use or generation of confidential or sensitive data during research, 55.94% of respondents indicated that they occasionally had to handle this type of RD. In comparison, 38.44% reported that they never did. Conversely, 70.94% of the subjects included in the sample clearly understood who owned the intellectual property rights associated with the RD they handled.

3.4. Dimension 4: Infrastructure and services

With the support options for RD management that teachers and researchers would find beneficial or utilize at UCLV, the results were as follows:

- workshops on best practices for RDM (65.63%);
- more infrastructure and technical support (64.38%);
- develop an institutional RDR for access to and long-term preservation of RD (47.19%);
- communicate and provide information on the requirements of scientific journals with respect to RD (46.25%);
- institutional guidelines or policies for the treatment of RD (45.63%);
- services that can handle personalized consultations on RDM practices for research groups or specific projects (40.31%);
- include RDM in undergraduate and graduate curricula (37.5%); and
- consider the creation of RD for reuse and citation as a scientific result relevant to job evaluation (34.06%).

It is notable that a significant proportion of respondents indicated that they have engaged in collaborative research endeavors, with 28.75% reporting that they have consistently collaborated with other colleagues on their projects, 41.25% stating that they have done so in over 50% of their research endeavors, 25.94% indicating that they occasionally collaborate, and 4.06% indicating that they have never engaged in such collaborative efforts. Regarding RD sharing, 72.81% of respondents indicated that they used email, with 69.69% citing the use of portable storage devices, such as USB sticks and external drives, and 31.25% mentioning the use of cloud applications, such as Dropbox and Google Docs. Additionally, 23.13% of respondents reported the use of a shared storage facility.

Thirty-five percent of the surveyed teachers and researchers reported having encountered difficulties at some point in their efforts to collaborate with other professionals to facilitate an optimal exchange of DI. The primary challenges encountered were as follows:

- Identifying an appropriate shared storage solution (23.13%)
- Navigating data confusion due to lack of version control (7.5%)
- Addressing file identification issues stemming from file nomenclature challenges (6.56%)
- Resolving ownership rights concerns related to RD (5.31%)
- Mitigating legal complexities associated with the cross-border transfer of data (3.13%)

3.5. Dimension 5: Accessibility and reusability

The respondents indicated that their RD exchange has been established primarily with the following entities:

- peer reviewers of your publication proposals (51.56%)
- the scientific community of your academic and research domain (50.63%)
- selected members of the institution itself (40.94%)
- interested parties upon request (38.44%)
- all members of the institution (22.81%)

A total of 34.69% of respondents indicated that they secure their digital RD with the use of a password, while the remaining 65.31% did not. When asked about the licenses through which teachers and researchers socialize their DIs publicly, over 60% of the respondents stated that they do not use any or are unaware of the relevant license. Figure 3 illustrates the distribution of the responses in this regard.

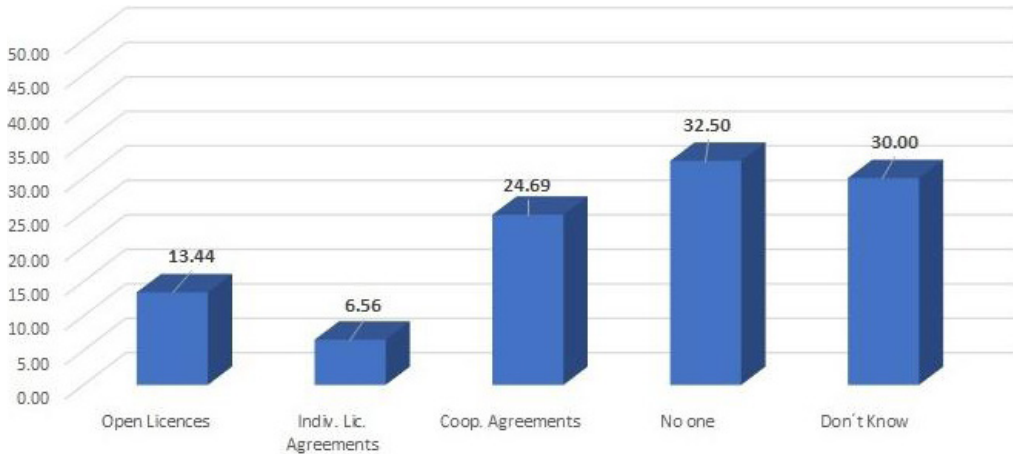

Figure 3. Percentage of use of licenses or other agreements used for the socialization of research data at the Universidad Central "Marta Abreu" de Las Villas. **Notes:** Open Licenses: open content licenses *(Creative Commons,* etc.); Individ. Lic. Agreements: individual licensing agreements; Coop. Agreements: cooperation agreements.

The respondents indicated that the two most significant motivators for openly sharing their RD were the prospect of greater visibility and impact of their research (70.31%) and recognition within the scientific community (68.13%; Figure 4).

When queried about the potential constraints on the open sharing of their RD, 40% of respondents identified the perceived risk of data misuse as the primary obstacle to sharing. Table 2 illustrates the predominant challenges cited by teachers and researchers in facilitating open RD sharing.

4. DISCUSSION

The preponderance of teachers over researchers can be attributed to the fact that Cuban universities have a predominant presence of this type of human resource, which is necessary to fulfill their primary function of academic training. A comparable outcome was documented by Borghi and Van Gulick (2021) and Elsayed and Saleh (2018). However, the university professor fulfills a dual role as teacher and researcher, as both activities are part of their job functions as established in the Regulations of Teaching

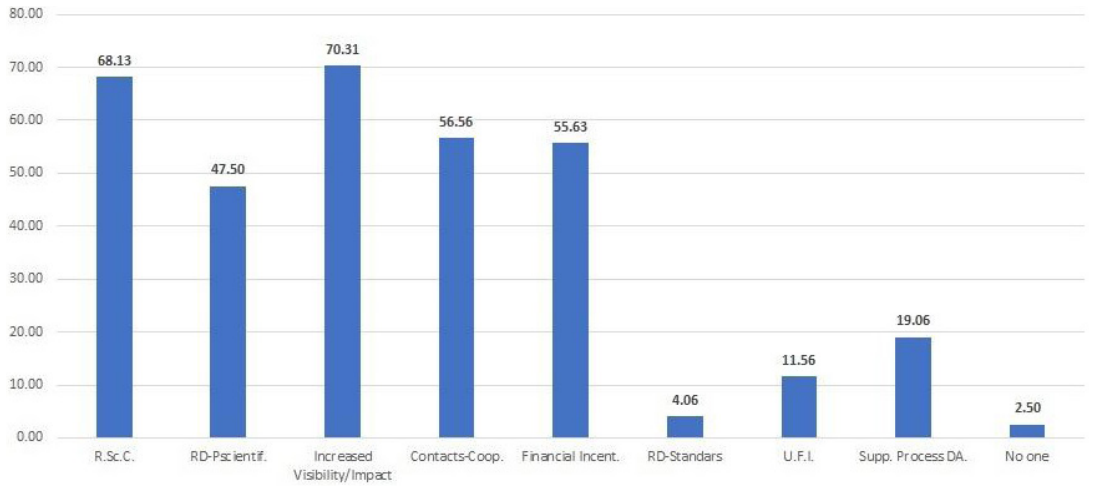

Figure 4. Incentives that could motivate teachers and researchers to share their research data openly. **Notes:** R.Sc.C.: recognition by the scientific community; RD-Pscientif.: consideration of RD as a relevant scientific production; Increased Visibility/Impact: increased visibility and impact of your own research; Contacts-Coop.: establishing new contacts and cooperation opportunities; Financial Incent.: Financial Incentives; RD-Standars. Use of DI: establish standards for the proper use of RD; U.F.I.: user-friendly infrastructure; Supp. Process DA.: supporting the process of making data accessible.

No.	The primary issue identified by teachers and researchers in sharing their research data (RD)	%
1	That openly shared RD is misused	40.00
2	Potentially undesired commercial use	31.88
3	There are legal restrictions on RD (copyright, patent law, trademark protection, usage protection, etc.) that do not allow open sharing	31.25
4	That there may be a violation of privacy	28.44
5	Lack of infrastructure for open sharing of RD	22.19
6	Risks of misinterpretation and/or falsification of RD	17.5
7	Increased effort, time consumption and/or increased costs for sharing RD	13.13
8	Lack of motivation for sharing RD	11.88
9	Increased competition in the dynamics of "publish or perish"	10.63
10	Lack of data standards	6.25
11	Missing data	2.81
12	Use of rare data formats	0.63

Table 2. Problems expressed by teachers and researchers to share their open DI.

Categories of the Ministry of Higher Education of Cuba (Republic of Cuba. Ministry of Higher Education, 2023).

The UCLV is the most multidisciplinary higher education center in Cuba. Its campus offers 52 degree programs that cover all areas of knowledge to a greater or lesser extent, which is why they were represented in the sample analyzed. Vallejo (2023) observed that the predominance of Social Sciences (Soc. Sc.) is reflected in the presence of two faculties of pedagogical sciences, one of sports sciences and one of social sciences. The classification system of the knowledge areas utilized situates the pedagogical sciences and sports sciences within the Soc. Sc.

The near-equivalence between the handling of quantitative and qualitative RD is attributable to the concurrent development of qualitative and quantitative research at the UCLV. As previously indicated, the institution unites specialties from both the socio-humanistic and

natural-technical branches, which exhibit a qualitative and quantitative predominance, respectively (Guzmán, 2021; Jiménez González, 2020; Taherdoost, 2022). Conversely, it is proposed that integrating data will facilitate resolving issues that cannot be addressed by analyzing data of a single type (Campos de Oliveira, 2020). It was anticipated that researchers in the field of health sciences would utilize clinical RD. However, it was observed that most of them were natural sciences and engineering professionals. This is because a considerable body of research in the latter two areas has significantly impacted human health.

The prevalence of text documents and spreadsheets as the most commonly used formats for digital data has been previously reported by other researchers (Elsayed and Saleh, 2018). It is incongruous that a significant proportion of respondents (>60%) indicated that they document their DIs in accordance with institutional guidelines. This is particularly noteworthy given that UCLV lacks a formal policy or standardized procedure for documenting the data stored and preserved within its digital infrastructure. This gives rise to the following hypotheses:

- There is a lack of clarity among researchers and teachers regarding the meaning of documenting and using metadata to describe RD.
- The documentation and description levels of the RD are executed at a basic level that does not allow compliance with FAIR principles (Findable, Accessible, Interoperable and Reusable).

Another contradictory result was the use of institutional templates for the DMP, given that the UCLV has not established the use of this type of plan for its research projects. The DMP has gained relevance to the same extent that the RDM has developed. An increasing number of entities that finance national and international projects have incorporated the presentation of a project proposal that includes the PGDI for the project as a requirement for receiving their funds (Cox and Verbaan, 2018; Lefebvre *et al.,* 2020). Therefore, it is recommended that both the UCLV and the rest of the Cuban scientific institutions should implement the DMP as an adequate practice in line with existing standards, particularly given that the Ministry of Higher Education itself has already begun to recognize RDM as a necessary component of scientific development (Republic of Cuba. Ministry of Higher Education, 2024).

Notwithstanding the existence of an infrastructure that has enabled UCLV to develop its own cloud storage service *(NextCloud),* the proportion of subjects who store and preserve their RD on personal computers, USB memory sticks, and external disks—devices with a high propensity for damage due to constant manipulation or vulnerability to virus attacks—was noteworthy. While personal computers have been identified as the preferred medium for RD storage and preservation in other studies (Krahe *et al.,* 2020; Mwinami *et al.,* 2024; Tenopir, 2020), this, coupled with the observation that a considerable number of subjects did not employ institutional servers for data. This is directly related to the 54.69% of teachers and researchers who suffered loss of their RD. The use of more vulnerable devices or storage spaces, without backup copies, increases the likelihood of damage to data, which negatively affects the availability of these for the project itself and other research initiatives in the future (Mwinami *et al.,* 2024). Furthermore, this practice hinders the discovery and accessibility of RD, thus impeding the fulfillment of the FAIR data stewardship principles (Currie & Kilbride, 2021).

Some studies have identified the issue of copyright and licensing as a significant barrier to the socialization of open RD (Navarro Molina & Melero, 2019). Consequently, this should be a subject of continuous updating for teachers and researchers of the UCLV, given that, as evidenced by the findings, slightly over 50% of respondents indicated concerns regarding data management from a legal standpoint. Furthermore, in addition to providing courses and workshops, establishing a legal advice service for the RDM is an effective solution.

The fact that 65.63% of respondents requested workshops, training, and training on RDM is a positive outcome, as it demonstrates a clear interest in acquiring knowledge and skills to enhance the management of RD. Furthermore, this constitutes a demand that can be assumed by areas such as the university library. These institutions have increased and strengthened their participation in data management, mainly through specialized services in training

and advising researchers and in data curation and other elements of RDM (Angelozzi, 2020; Sheikh *et al.,* 2023; Xu, 2022).

The UCLV currently has an institutional digital repository through which it disseminates its scientific production (Machado Rivero *et al.,* 2016). This platform can contribute to the limited socialization of certain level of RD. However, the implementation of institutional repository for RD is necessary. Conversely, the infrastructure has enabled the institution to develop its own cloud storage service *(NextCloud),* which can meet at least a significant portion of the storage and preservation requirements for the DI utilized within the institution.

Formulating a regulatory framework for RDM represents a crucial step in implementing best practices for data management. At the institutional level, UCLV is engaged in the formulation of a policy proposal, with the assistance of the RDMS-LatAm (international project supported by VLIR-UOS) and a national project named "Research Data Management in Cuban Higher Education and Scientific Institutions". Moreover, the institution has initiated the implementation of undergraduate and graduate courses to equip the academic community with the requisite skills (Machado Rivero, 2024). The proportion of respondents who have employed a foreign RDR to preserve and disseminate their DIs is notably low (1.56%). This is believed to be a consequence of the limited awareness and uptake of RDR, coupled with the accessibility and cost-free nature of such platforms. An illustrative example is Zenodo, an IDN developed by CERN as part of an initiative sponsored by the European Commission (Martínez Méndez *et al.,* 2023).

The preservation of RD after the project's conclusion is evidenced by the practice assumed by approximately two-thirds of the respondents, which is a positive outcome. Nevertheless, the practice of preserving RD on personal devices rather than in repositories or storage systems with enhanced accessibility, visibility, security, and interoperability makes it challenging for these data to comply with the FAIR principles (Currie & Kilbride, 2021) and to enhance their reuse and impact.

The primary exchange of RD was primarily with the referees of scientific journals and professionals in their respective academic and research domains. This is justified by the life cycle of scientific research, which necessitates the publication of results (Estevão *et al.,* 2024; Sedki, 2022). Furthermore, there is a considerable pressure to publish, often referred to as "publish or perish," which has resulted in a significant increase in number of publications at both the individual and institutional levels (Borghi & Van Gulick 2021; Steingard & Rodenburg, 2023).

It is imperative to address the significant proportion of teachers and researchers who have not utilized appropriate licenses to disseminate their data. The utilization of open licenses is paramount to ensure the ethical and legal reuse of datasets and acknowledge copyright within the domain of open science (Sheikh *et al.,* 2023). Furthermore, it provides the foundation for asserting claims in the event of unauthorized uses. The widely recognized *Creative Commons* licenses can be employed, or other licenses developed by the authors or the institution (Contreras, 2023).

5. CONCLUSIONS

The practice of RDM is undergoing a period of consolidation, with a growing emphasis on ensuring the transparency, veracity, reproducibility, reusability, and impact of scientific results. University institutions have historically been at the vanguard of this field, and their role in its development and dissemination will continue to be pivotal.

UCLV is one of the most prolific universities in Cuba, producing a substantial and diverse array of RD across numerous disciplines. Applying the present diagnosis permitted the conclusion that the RDM in this institution is in an incipient stage and significantly lags behind the standards that already exist at the global level.

The institution must implement policies that encourage adopting appropriate data management practices for its sponsors' research projects. The willingness of teachers and researchers to acquire the requisite knowledge and skills to adopt RDM as a work philosophy and standard was evident. Conversely, the already existing technological infrastructure and some trained specialists place UCLV in a favorable position to achieve results and assume the changes that open science generates in scientific and higher education institutions.

Conflict of interests

The authors declare that there are no conflicts of interest.

Contribution statement

Conceptualization, writing – original draft, writing – review & editing: Manuel Osvaldo Machado Rivero, Dianelis Olivera Batista.

Data curation, formal analysis, funding acquisition, investigation, methodology, software, resources, validation: Manuel Osvaldo Machado Rivero, Dianelis Olivera Batista, Grizly Meneses Placeres, María Josefa Peralta Gonzalez, Sadia Vancauwenbergh.

Project administration, supervision: Manuel Osvaldo Machado Rivero.

Supervision: Manuel Osvaldo Machado Rivero.

Visualization: Dianelis Olivera Batista.

Statement of data consent

The data generated during the study have been included in the article.

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