

Implementation of FAIR Guidelines in Selected Non-Western Geographies

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Keywords: FAIR Guidelines, FAIR implementation, non-Western geographies

Citation: Lin, Y., Purnama Jati, P.H., Aktau, A., Ghardallou, M., Nodehi, S., Van Reisen, M.: Implementation of FAIR Guidelines in selected non-Western geographies. *Data Intelligence* 4(4), 747–770 (2022). doi: 10.1162/dint_a_00169

Submitted: March 10, 2021; Revised: June 10, 2022; Accepted: July 15, 2022

ABSTRACT

This study provides an analysis of the implementation of FAIR Guidelines in selected non-Western geographies. The analysis was based on a systematic literature review to determine if the findability, accessibility, interoperability, and reusability of data is seen as an issue, if the adoption of the FAIR Guidelines is seen as a solution, and if the climate is conducive to the implementation of the FAIR Guidelines. The results show that the FAIR Guidelines have been discussed in most of the countries studied, which have identified data sharing and the reusability of research data as an issue (e.g., Kazakhstan, Russia, countries in the Middle East), and partially introduced in others (e.g., Indonesia). In Indonesia, a FAIR equivalent system has been introduced, although certain functions need to be added for data to be entirely FAIR. In Japan, both FAIR equivalent systems and FAIR-based systems have been adopted and created, and the acceptance of FAIR-based systems is recommended by the Government of Japan. In a number of African countries, the FAIR Guidelines are in the process of being implemented and the implementation of FAIR is well supported. In conclusion, a window of opportunity for implementing the FAIR Guidelines is open in most of the countries studied, however, more awareness needs to be raised about the benefits of FAIR in Russia and Kazakhstan to place it firmly on the policy agenda.

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ACRONYMS

AOSP	African Open Science Platform
CODATA	Committee on Data for Science and Technology
CREMLINplus	Connecting Russian and European Measures for Large-scale Research Infrastructures-plus
DMP	data management plan
EAC	East African Community
FAIR	Findable, Accessible, Interoperable, Reusable
FDP	FAIR Data Point
ISC	International Science Council
IT	Information Technology
NARO	National Institute of Agriculture, Forestry and Fisheries (Japan)
NDMS	National Data Management System (Russia)
OAIR	Open Access Institutional Repository
RDM	Research Data Management
ROMOR	Research Output Management through Open Access Institutional Repositories in Palestinian Higher Education
VODAN	Virus Outbreak Data Network

1. INTRODUCTION

The implementation of the FAIR Guidelines—that data be Findable, Accessible, Interoperable and Reusable (FAIR)—enhances the ability of data to be found and reused by humans and machines. These principles have been recognised by academics and researchers, as well as many other stakeholders including healthcare practitioners, scientists, data managers, publishers, policymakers and funding agencies. With FAIR Guidelines, a different mindset is emerging about the use of data and the relationship between data providers and users globally. However, since the FAIR Guidelines were first discussed in 2014, these principles have been mainly implemented in Western geographies (81%): 67% in European geographies and 14% in North American geographies [1]. The Southern and Eastern hemispheres have been largely excluded from implementation efforts up to this point [1]. This raises the question as to whether or not FAIR is under discussion in other places and how conducive the environment in these places is to adopting and implementing the FAIR Guidelines. This study, therefore, examines the possibility of implementing FAIR in non-Western geographies, where English is not the main language.

2. METHODOLOGY

For this study, a systematic review of the literature was conducted to determine whether or not FAIR is being implemented in non-Western geographies and, if not, the potential for such implementation. A specific search strategy (Appendix 1) and selection process were formulated for literature published between 2014 and 2021 in the selected geographies. In many places, languages besides English are used

intensively for publication. Thus, it was necessary to explore non-Western publications. The non-Western geographies included in the study were: Indonesia, Japan, Kazakhstan, Russia, the Middle East (including Saudi Arabia, Kuwait, United Arab Emirates, Qatar, Bahrain, Oman) and selected African countries (Egypt, Tunisia, Kenya, Zimbabwe, Uganda and South Africa).

In terms of the search strategy, it was decided to use local databases and search engines providing data written in local languages. In relation to Japanese literature, the most leveraged literature databases in Japan were used, namely, CiNii, J-Global and researchmap.jp, as well as the most popular search engine, yahoo.co.jp. The specific search strategy (keywords connected with Boolean operators) was defined and is shown in Appendix 1. Keywords included, but were not limited to 'FAIR', 'data' as well as the translation of the word 'data' in the respective languages. The time frame for the search was from 2014 to 2021, because the FAIR Guidelines started gaining attention in 2014. Google Scholar was also used as a supplement to find resources. Finally, yandex.ru was used to find literature in Russian language, as it is the most used search engine in Russian speaking regions.

The selection criteria for the literature were defined. Articles written in languages other than English that contain keywords and discuss the introduction or the adoption of FAIR Guidelines in specific regions or countries were selected. Articles written in English and that focus on applying FAIR data in geographies located in the Southern and Eastern hemispheres were also chosen, as English is the dominant language for scientific publications. The selection was further refined using inclusion and exclusion criteria. Literature was included if the FAIR Guidelines were implemented to make a novel and concrete academic proposal in the study, and grey literature was included if cutting-edge policies in terms of FAIR were mentioned. On the other hand, literature was excluded if duplication was identified or if the content was considered irrelevant (by screening abstracts and titles) or assessed as non-eligible. Among the selected literature, two masters theses from co-authors, Putu Hadi Purnama Jati and Aliya Aktau were included, as they reflect the latest local developments in adopting FAIR Guidelines in Indonesia and Kazakhstan. The selection process is illustrated in the following workflow (Figure 1).

The literature was collected and stored in an Excel file with detailed information such as geography and language. The results of the search of the literature are shown in alphabetical order in Table 1. The publications written in a language other than English are given in Appendix 2.

Qualitative data analysis was performed using open, axial and selective coding as a grounded theory method. The reason for choosing this method is that the concepts emerge from the raw data and are later grouped into conceptual categories in the process of open coding, with the goal to build a descriptive, multi-dimensional preliminary framework for later analysis. By doing so, the process itself ensures the validity of the work, as it comes directly from the raw data [2]. Axial coding was then conducted to relate codes (categories and concepts) to each other through a combination of inductive and deductive thinking. As a final step, the selective coding was used to gather a complete picture of the information obtained during the data collection process [3]. The results of selective coding, based on each non-Western geography, were further classified as recognition of the issue (the need to make data findable, accessible, interoperable,

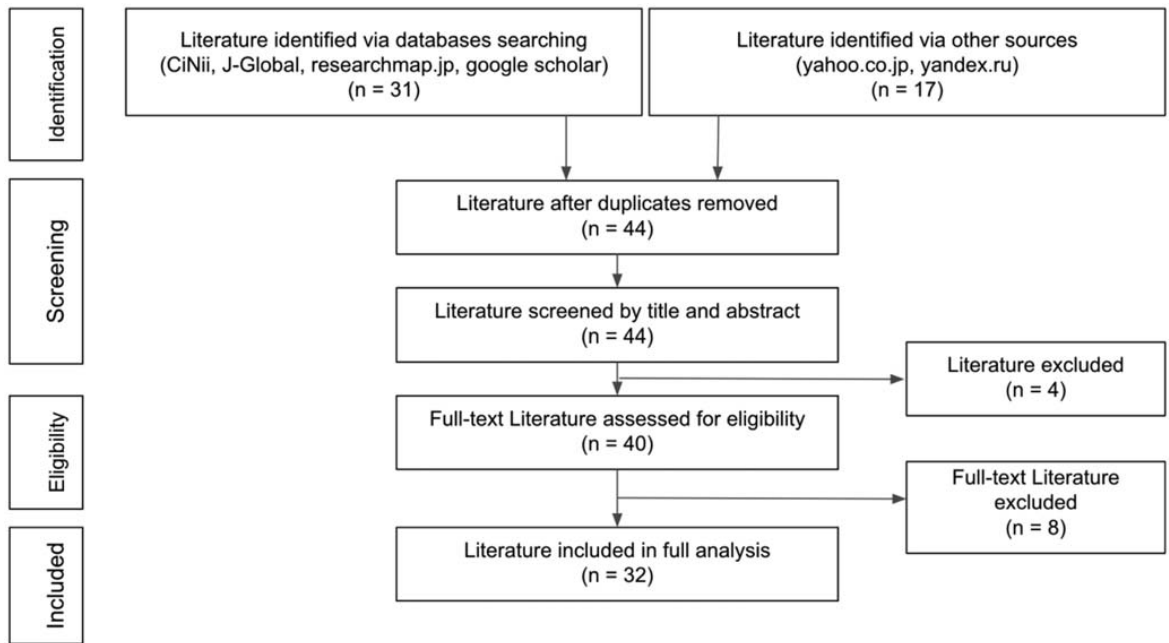


Figure 1. Workflow for the identification of qualified literature for review.
Source: Created by author, Yi Lin

Table 1. Search results: Location, number of resources, language.

Location	Number of resources	Publication language
Africa	13	English
Middle East	2	English
Indonesia	1	Indonesian
Japan	5	Japanese
Kazakhstan	1	English
Russia	4	Russian
	3	English
Total	32	

Note: The Middle East and African countries covered in this study are Saudi Arabia, Kuwait, United Arab Emirates, Qatar, Bahrain, Oman, Egypt, Tunisia, Kenya, Zimbabwe, Uganda and South Africa.

and reusable), the implementation of FAIR Guidelines is seen as a solution, and a climate for change exists. It was then possible to identify if a window of opportunity was open in the particular country for the potential adoption of FAIR. The results are presented in the next section.

3. RESULTS: IMPLEMENTATION OF FAIR

3.1 Indonesia

In Indonesia, there have been problems with data gaps among government ministries and institutions. In government agencies, land data, agricultural production, and unemployment can be controversial and are heavily discussed. In 2016, in a meeting to coordinate the economic census, the President of Indonesia expressed his dissatisfaction with the lack of data sharing and the inconsistencies in data from government agencies [4]. As a result of the weak collaboration between government agencies, the government has been unable to optimise its data management and effectively use the data it currently has [5].

In order to solve its data management problem, the Government of Indonesia wants to increase the integration, synergy and the coherence of data generation [6]. Towards this end, various meetings and in-depth discussions have been held by ministers and heads of departments [6]. As a result, the Indonesian government has come up with a two-pronged strategy for data management, which is being implemented under Satu Data Indonesia.

The first part of the strategy is enhancing collaboration by developing an organisation for data production within the government. Under this arrangement it is believed that sectoral fragmentation can be eliminated and collaboration facilitated, as the project forces all relevant ministries and agencies to communicate before the publication of information [5]. The second component is the data principle. The Indonesian government believes that rules for data production are needed, in addition to coordination. Therefore, four data principles have been initiated: (i) data has to conform with data standards, (ii) metadata has to be available, (iii) data must be interoperable, and (iv) a reference code for data must be used. Although the Indonesian government's data principles do not mention FAIR, Satu Data Indonesia has some similarities with FAIR. It follows the FAIR Guidelines in the following ways [5]:

- The data standards and code reference requirement of Satu Data Indonesia follow the third facet[Ⓞ] of the FAIR Guideline 'Reusability' (R1.3), which requires data to meet domain-relevant community standards.
- Satu Data Indonesia's interoperability principle follows the FAIR Guideline of 'Interoperability', which requires data to be interoperable.
- Satu Data Indonesia's metadata principle follows all the facets of the FAIR Guideline of 'Findability' (F1, F2, F3, F4) and the first facet of 'Reusability' (R1) in relation to the metadata requirement.

[Ⓞ] There are 15 facets of FAIR: F1, F2, F3, F4, A1, A1.1, A1.2, A2, I1, I2, I3, R1, R1.1, R1.2, and R1.3.

Three out of four of the principles of Satu Data Indonesia are identical to FAIR: data should conform to data standards, metadata should be accessible, and data should be interoperable.

While FAIR is not mentioned in Satu Data Indonesia, awareness of FAIR exists among Indonesia's academia. Hence, the idea of FAIR data as a strategy for data management is not simply an administrative movement, but plays an important role in guiding scientists in the proper collection, storage and sharing of research data in a sustainable way [7]. Moreover, FAIR data was mentioned as one of the main criteria for complying with the Open Science Framework (OSF) dynamic repository and static institutional repository. In 2020, Indonesia's science repository clearly stated in its guidance that the FAIR Guidelines are to be implemented to support open science [8].

As mentioned above, Indonesia is implementing strategies to improve data management by streamlining the data from various government agencies [5]. Satu Data Indonesia was published in 2019 to guide the coordination and implementation of data management principles by Indonesian ministries and agencies to improve the quality of data produced by the Indonesian government. The Ministry of National Development is the driving force behind Satu Data Indonesia and has consistently suggested that the President of Indonesia regulate it. In addition, researchers in Indonesia have increased their awareness of data management by implementing FAIR Guidelines to support open science. Therefore, it appears that there is a window of opportunity open for the implementation of FAIR, as there is evident potential to implement the FAIR Guidelines in Indonesia by extending the model for the management of government data as well as data in research repositories.

3.2 Japan

Regarding the adoption of FAIR in Japan, most of the scenarios are about the improvement of the distribution of research data, although the specific context varies. For example, due to the explosion of digitised data in the field of agricultural research, it is necessary to establish an approach to collecting and managing such data efficiently to improve the research environment, as well as to provide mechanisms to facilitate the application of statistical analysis and machine learning. On the other hand, a new approach under the frame of a central data management system is considered necessary in order to increase the legitimacy of research data and avoid data breaches. Therefore, the Government of Japan has launched a new data management strategy to support universities and research institutes focusing on data archiving, management and queries [9].

At the same time, some FAIR equivalencies are being discussed by academics in Japan, and some have even been adopted by Japanese research institutes [9]. For example, Dataverse (<https://dataverse.org>), developed by Harvard University, is one of the systems adopted by Japanese institutes. Dataverse is also used by the French public research institute dedicated to agricultural science (INRA) and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). This platform increases the accessibility and reusability of data. In 2020, the National Institute of Informatics in Japan decided to adopt GakuNin research data management (RDM) (<https://rdm.nii.ac.jp>), which is a localised open-source software based

on the Open Science Framework (OSF: <https://cos.io/our-products/osf>) stemming from the Center for Open Science in the United States. GakuNin is a platform for accessing research data in a sharable manner, similar to J-STAGE Data, which is another FAIR equivalent platform. However, the aforementioned systems and services all have a problem in terms of accessibility, to various extents, due to the fact that the design purpose is to protect research data. For example, problems with accessibility occur when shared folders are used in the built-in database. In particular, this refers to automatic modification triggered by adding unique IDs and the fact that changing organisations results in the automatic inheritance of access rights from the parent directory. The authority of accessibility is also automatically identified by checking whether data fields (e.g., funds and licence, confidentiality types, and personal information) exist. Moreover, specialised functionalities are required in the field of agriculture in relation to setting up metadata freely, the use of agricultural terminology, and data querying [9].

In terms of FAIR equivalence, the data management plan (DMP) templates in Japan are in line with the FAIR Guidelines. A DMP is a plan for how to manage, handle, maintain, store and publish data collected and created for research, and can maximise the value of investments in research results by enabling the reuse of data and ensuring that data is managed efficiently and appropriately [10]. If DMP templates can be created and implemented flawlessly, the data is able to be reused over time. OpenAIRE and the European Commission's FAIR data experts conducted a survey[®] on templates among DMP creators and support staff in 2017 [11]. Approximately 60% of respondents perceived the process of creating and supporting DMP templates positively, and 16% perceived viewed it negatively. However, there is concern that researchers might have to spend too much time making DMP templates, the purpose of which is to save them time. Therefore, there is a need to develop a DMP tool. Based on the output of the DMP, the author has further analysed the discussion and discoveries to the RDM tool in the next section [12].

In relation to the adoption of FAIR in public research (e.g., by national universities), there has been an emphasis on increasing data reusability and preventing academic dishonesty. For example, institutional research organisations like national universities have allocated significant financial and human resources to research activities since institutional research (IR) was introduced in Japan in early 1990s, but there are still problems with regards to the lack of professionals and technological skills. Tasks that require information technology (IT) solutions are usually outsourced, which generates concern about data security [13].

Last, but not the least, FAIR data has also been implemented in citizen science, interlinked with community-based participatory research for solving socio-environmental issues [14]. In a recent study by Kondo et al. in 2019, a theoretical framework called 'open team science', featured in a data visualisation method based on the FAIR Guidelines, was created and will be tested using case studies [15].

Various strategies are needed to deal with the issues outlined above. First of all, a data scheme for the new system, called the Linked Database (narolin DB), has been proposed by the National Institute of Agriculture, Forestry and Fisheries (NARO) in Japan. This scheme is guided by the Japanese government in

[®] To which they received 289 responses.

terms of building the research data repository and is based on the FAIR Guidelines. The main purpose is to improve the reusability, interoperability and shareability of research data by implementing metadata. In addition to typical metadata (such as title, author name, date, keywords and location), customised NARO Commons metadata keywords have been created. For example, there are numerous data classification to indicate research categories (10 big groups, 60 middle groups, and 106 small groups), more than 21,000 translatable keywords, and terminology about more than 14,000 species. All metadata are stored in Excel and uploaded together with original data to the system [9].

Secondly, based on the findings on the DMP tool, it is considered necessary to decrease the burden of making templates on researchers and improve the reusability of research data. Hence, next-generation DMPs are needed that encompass the FAIR Guidelines, as well as the standardisation of DMPs and development of active DMPs. In response, a RDM rubric has been developed to support researchers and libraries in Japan. These RDM evaluation tools, which were developed to suit the situation in Japan, are considered to be useful for researchers and research institutions to visualise inadequacies and examine priorities. These tools have been used by researchers in Japan and the results provide a clue to understanding the needs in constructing the RDM service [12].

Thirdly, checklists based on the FAIR Guidelines can be applied to institutional research data in national universities in Japan. These checklists can be used when the system is updated or modified. Such checklists would also help university staff to understand the task better in terms of the requirements for institutional research interoperability in certain systems. In particular, the FAIR Guidelines allow users to add a unique ID so that metadata holds explanatory information. This ID could be used by digital media and the network, while also making it possible to authorise accessibility. The shareability of metadata is important during the reconstruction phase, after data is collected, using analysis methods via a data warehouse. A system with the following four elements is proposed with regards to the definition of analysis methods via data warehouse and databases based on institutional research data, related to the maintenance and realisation of metadata: (i) metadata, (ii) entity-relationship diagram, (iii) star scheme, and (iv) online analytical processing (OLAP) [13].

Lastly, the framework 'open team science' was developed in the Biwa Lake case study to achieve boundary spanning with the transcend method and the goals were discovered and shared, allowing actors with different interests to cooperate. The results of the questionnaire survey were disclosed as FAIR data. Experience and lessons learnt can inform subsequent stages or new projects as input resources. In the authors' opinion, it is thus possible to bridge these boundaries by sharing information, knowledge and wisdom through appropriate visualisation and dialogue based on FAIR data [14].

A new integrated innovation strategy was approved by Japan's Ministry of Health, Labour and Welfare in 2018. The purpose of this strategy is to promote the formulation of data policies not only in the national research institutes under its jurisdiction, but also in national experimental research institutes and independent administrative agencies. The government white paper claims that, as one of the requirements for data management, the FAIR Guidelines should be followed to enable research data to be found, accessed,

shared, and machine-readable in order to increase the efficiency of data-use in the research context [16]. In line with this new data policy, the implementation of FAIR data in Japan has been stepped up among diverse actors. For example, NARO is responsible for constructing the new system to improve the quality of research data management in the field of agriculture. The Japan Science and Technology Agency (JST) has claimed that it was necessary to develop a DMP since 2017, and in 2018 the New Energy and Industrial Technology Development Organization (NEDO) and the Japan Agency for Medical Research and Development (AMED) expressed the same view [10].

The shareability of research data in open science is also being addressed and it is necessary to find a solution to enable researchers, research institutions, libraries, and other stakeholders to use research data in open science. With regards to community-based participatory research, researchers and societal stakeholders (such as governmental agencies, industries, non-profit organisations and civil society) share leadership roles to reach decisions. They work collaboratively to design research agendas, find solutions, produce knowledge, and disseminate the results [17]. Collaborative learning and the integration of information through mutual understanding between different actors is particularly important during this process [23, 24].

3.3 Kazakhstan

Since 2013, Kazakhstan's focus in the field of digital healthcare has been on establishing an integrated information environment, as the basis for personalised and preventive healthcare services [20]. The country has allocated resources for integrated data infrastructure to improve people-centred health systems, including through an Interoperability Platform, designed to address data fragmentation issues. To this end, 22 health information systems provide statistics and analytics in Kazakhstan for better decision-making. Although the implementation of the Interoperability Platform has been finished, the platform has not yet gone live and, therefore, data remains fragmented at the level of healthcare organisations, as it cannot interact [21].

According to the World Health Organization (WHO) in Kazakhstan [22], one of the top three challenges in the country is to develop capacity for handling data. The volume of data has grown rapidly in recent years, making it necessary to not only improve the quality of data for interested parties and medical personnel to easily access, but also to allow data to interact to facilitate the provision of healthcare services as well as medical research. Because the introduction of the Interoperability Platform has been unsuccessfully [23], data is still not findable, accessible, or interoperable and, therefore, cannot be reused by healthcare organisations. The FAIRification of data can address these issues, allow for the discovery of meaningful patterns, and contribute to better decision-making, as well as saving billions of euros [24].

Health-related issues in Kazakhstan are identified by the Ministry of Health, which is pursuing reforms and policies aligned with the national strategies [25]. To address the issue of data fragmentation, the Ministry of Health has launched a number of programmes since 2013, which use international standards and vocabularies and show a willingness to participate in global science. This may prompt the development of a FAIR Data Point (FDP) for digital healthcare in Kazakhstan, contributing to the development of medical science in Kazakhstan and open science globally.

In order to achieve sustainable development for the adoption and implementation of FAIR data, a favourable environment, including an institutional framework, standards, data and funding for use-cases must be provided, rather than investment in any particular technology [26]. In this regard, the Government of Kazakhstan is willing to develop a healthcare data infrastructure to serve as the foundation for the provision of healthcare and medical research. A strong political resolution to improve health outcomes is evident in a number of the recent reforms, including the digital health concept 2013–2020 [27], Densaulyk 2016–2019 [28] and State Health Development Program for year 2020–2025 [21]. All of these policies and programmes endorse the interoperability of data and its efficient (re)use.

However, to implement FAIR data in Kazakhstan, awareness about FAIR needs to be raised more broadly. If stakeholders understand the benefits that FAIR could bring to the country, their interest in FAIR may increase. However, as the people of Kazakhstan are used to a top-down approach, the government needs to reach out through people who understand the value of FAIR data and promote it from bottom to top. Combining both bottom-up and top-down approaches might yield results in terms of the acceptance of FAIR in Kazakhstan, leading to its adoption.

3.4 Russia

In Russia, from a technological point of view, there is a problem with the logical integration, harmonisation, and unification of heterogeneous data from different sources, specifically, interdepartmental government information systems (electronic services) [29]. In addition, a single form of scientific data representation and data management is lacking in the scientific community in Russia [35–37]. The key problem is not about collecting, publishing and storing information, but about ensuring the findability, accessibility and reusability of data, including on other platforms. FAIR data not only enables scientific results to be shared in a form that is understandable by investors, government agencies and the public, but can also ensure control over a large amount of scientific data [30].

In December 2018, Russia introduced the National Data Management System (NDMS) as part of its national programme ‘Digital Public Administration’, to overcome the lack of logical integration, harmonisation and unification of heterogeneous data generated from various sources. The NDMS has been crafted with the purpose of repairing the fragmented information systems across the various ministries and departments (electronic services), as well as enabling their interaction (interoperability). As this is a large-scale and complex project, the solution was first tested in the Arctic macro-region [29], after which it is scheduled to be rolled out across the rest of Russia.

The main goal of the NDMS is to increase the efficiency of the creation, collection and (re)use of state data for the provision of state and municipal functions, and to meet the needs of individuals and legal entities in terms of access to information. FAIR is seen as one of the most succinct frameworks for overcoming data fragmentation. Hence, the adoption of FAIR is considered to be the next step in the management of data in Russia [29].

Work is also underway in Russia to ensure access to information and data processing in the scientific field and appropriate regulatory mechanisms are being developed. The Connecting Russian and European Measures for Large-scale Research Infrastructures-plus (CREMLINplus) project is being developed by Russia and the European Union to expand ties in the field of scientific and technical cooperation. This project is based on providing international access to the Russian research infrastructure, as well as facilitating the exchange of knowledge. The FAIR Guidelines are included in CREMLINplus in terms of the accessibility of data from European research groups by Russian scientific infrastructure [30]. The FAIR Guidelines can facilitate the integration of Russian research infrastructure with European research infrastructure, as well as provide a basis for developing similar data management rules.

The NDMS concept considers FAIR data to be the foundation of the main international conceptual requirements for data, and the FAIR Guidelines are already included in CREMLINplus. Both policies recognise the need for the compatibility of data in different organisations and their effective use, which is important for analytics and decision-making processes led by stakeholders from the central government. In addition, the introduction and possible implementation of FAIR data was discussed in several articles funded by the Russian Academy of Sciences [38–40]. Adopting FAIR in the management of research data in order to effectively manage the data lifecycle in science is one of the concerns of Russian academia. Although the findings indicate that there is potential for the adoption of FAIR in Russia, locally-owned data management practices are still preferred, which means that a window of opportunity is not entirely open and more awareness raising of the benefits of FAIR needs to be undertaken before it could firmly be on the policy agenda.

3.5 Middle East

In the Middle East, there are many challenges with the management and sharing of research data. A recent study found that more than half of Arabic researchers in Egypt, Jordan and Saudi Arabia had no DMP and 42% were unfamiliar with such plans [36]. Hence, it appears that this step in the research lifecycle is a new concept for researchers. In this study, researchers were concerned more about issues of confidentiality in relation to providing access to their research data [36]. In the same vein, a study by Malone, which looked at the data sharing practices and perspectives of scientists in the Middle East (in Gulf Cooperation Council countries[®]), also indicated that the majority of researchers (72%) are either not required to have a DMP as part of their research project or do not know if one is required [37]. This common practice may explain the almost complete absence of articles documenting the use or implementation of FAIR Guidelines in the Middle East.

Governmental bodies, especially higher education institutions, are at the cutting edge of scientific research in the Middle East. However, this research faces many challenges, such as a lack of focus with respect to research priorities and strategies and insufficient funding to reach research goals. Despite the fact that sharing research data has been recognised as a strong scientific need, several major research efforts in

[®] Saudi Arabia, Kuwait, the United Arab Emirates, Qatar, Bahrain, and Oman.

the region—such as the Arab Strategy for Scientific and Technical Research and Innovation; the National Policy and Strategy for Science, Technology and Innovation 2013–2017 in Jordan; the Science, Technology and Innovation Policy in the United Arab Emirates; and the National Strategy for Science, Technology and Innovation 2015–2030 in Egypt—have restricted the sharing of research data, which impacts not only on how they profit from research outputs and published articles, but also how researchers in the Middle East can exchange published research outputs. Furthermore, no focus is given to unpublished data sets or raw data [37].

Despite this, some initiatives in this field deserve to be mentioned. First, there is Research Output Management through Open Access Institutional Repositories in Palestinian Higher Education (ROMOR), launched in 2016 under the auspices of the European Union’s Erasmus Plus programme. Over the course of three years, this project aimed to build capacity for research output management in four Palestinian universities by establishing Open Access Institutional Repositories (OAIRs) based on the FAIR Guidelines in order to increase the accessibility, interoperability and reusability of research data [38]. Secondly, we can also point to the experience of using a digital data management system called ‘Lesionia’, which is an open-source web application for the collection, management and analysis of clinical and epidemiological data related to patients suspected of having cutaneous leishmaniasis. It was initially conceived and developed in the frame of the PEER518 project, funded by the United States Agency for International Development-National Academy of Sciences (USAID-NAS). This system is meant to enable researchers within the project consortium to enter and access data using the FAIR criteria. The project consortium included nine institutions based in five countries: Tunisia, Morocco, Lebanon, Mali and the USA [39].

Although a window of opportunity for the implementation of FAIR is not quite open in the Middle East, countries in the region are in the early phase of data sharing and have identified the problem (lack of data sharing and management policies and formal mechanisms for openly sharing data) and are working towards a solution. This process can be pushed forward through partnerships with transnational universities—and the mood seems to be receptive of this now, as evidenced by the various projects discussed above. These international collaborations with experienced researchers can promote a culture of research and pave the way for the implementation of FAIR.

3.6 African Countries

3.6.1 Continental Level

In Africa, the focus brought by about by the FAIR Guidelines is on digital health initiatives, which currently suffer from a lack of capacity to share health data among stakeholders in the health sector. For instance, the multiple health data systems in Africa were not connected during the Ebola outbreak that occurred in West Africa from 2013 to 2016. Therefore, major challenges were faced in containing the disease [40]. Since early 2020, the COVID-19 outbreak has resulted in significant loss of life, as well as economic loss, in Africa and the world. Although suboptimal data management and data reuse have been leveraged during this epidemic, as with the Ebola epidemic, access to valuable data about past epidemics,

and the current one, has not been provided equally for different populations in different places on the African continent [41]. These experiences have sparked the African community to consider a digital solution for current and future outbreaks, namely, a digital platform to increase the accessibility of health data.

On a continental level, various initiatives have been taken to examine data issues occurring in Africa. One example is the African Open Science Platform (AOSP), which has been launched to bring African scientist to the cutting edge of modern technology, so that data-intensive science can be used to solve the challenges being faced. In addition to AOSP, there are several sister initiatives, such as the GO FAIR Implementation Network Africa (IN-AFRICA) and the Committee on Data for Science and Technology (CODATA). The aim is to cover FAIR and open science infrastructure in Africa to enable smooth access to data and provide enhanced computing capacity [42].

During the COVID-19 pandemic, besides the community healthcare providers holding the first line of defence against coronavirus, experts from other domains have also contributed to the fight, including computer and data scientists. The researchers are dedicated to providing understandable artificial intelligence (AI)-ready data for machines to conduct analytics to discover patterns in epidemic outbreaks so that the impacts of the virus can be mitigated. In order to provide machine actionable data, the Virus Outbreak Data Network (VODAN) Implementation Network (IN) was created by CODATA, together with the Research Data Alliance (RDA), World Data System (WDS) of the International Science Council (ISC) and GO FAIR. The FAIR-based project VODAN-Africa produces machine readable data in electronic health records using the FAIR Guidelines, together with technical ability and commitment from experts in the affected countries [41]. FAIR-based data and metadata ensure the discoverability of data. To implement this approach, FAIR (meta)data is opened up by publishing data on FDPs, enabling algorithms to find patterns by searching these (meta)data [43].

3.6.2 Regional Level

Plans on the regional level have also been drafted, especially in East Africa. These plans consist of an assessment of regional visions and goals and the actions required to achieve these goals—which has led to the creation of the Digital REACH Initiative. This plan brings together all the stakeholders from the East African Community (EAC) with the specific aim of improving health outcomes across the region through the use of digital health. It is believed that coordination in digital health will result in economic efficiencies, including the sharing of digital health resources across the region; improvements in health systems through enhanced data sharing, policies and standards; and improved decision making through the use of data and disease surveillance [44].

One of the main potential health programmes discussed in this plan is the East Africa Open Science Cloud for Health (EAOSCH). This programme aims to create a supporting structure for the seamless sharing of health data across EAC partner states. Through this health programme, a real-time regional data warehouse is intended to capture, store, retrieve, analyse and manage national and regional health in East Africa. But in order to enable cross-border healthcare in the EAC region, harmonisation is required including

interoperable work stream sets and shared standards for digital health [44]. As the FAIR Guidelines articulate the attributes of data needed to enhance the reusability of data for both humans and machines [45], they have been proposed as a tool to enhance the reusability of data. The initiative finds that the establishment of this real-time data warehouse enhances the ability to share health data across the EAC.

3.6.3 Egypt and Tunisia

In North Africa, two data repositories were listed on re3data.org: the first being a government data repository in Egypt, namely, Egypt's Information Portal [46], and the second being the African Development Bank's statistical data portal Open Data for Africa, which includes Tunisia [47]. Although these two research data repositories provide open access to their data, and the terms of use and licences for the data are provided, they do not use a persistent identifier (PID).

More recently, in order to address the challenges caused by the COVID-19 pandemic, Tunisia also participated in the VODAN Implementation Network carried out by GO FAIR, in collaboration with other institutions, such as the Leiden University Medical Center (LUMC). This work aims to implement FAIR Guidelines in relation to non-patient COVID-19 data to establish the impact of the pandemic on migrants, refugees and asylum seekers from sub-Saharan African countries. The pre-FAIRification phase has been completed and the FAIRification phase is in progress. For the moment, data on migrants are available for consumption through an FDP-deployed and hosted on the website of the University of Sousse in Tunisia (<https://fdp.uc.rnu.tn>) [48]. The initiative VODAN-Africa is based on the FAIR Guidelines and involves, especially in the case of Tunisia, the University of Sousse as a partner. The main goal of this collaboration is to develop expertise on FAIRification through capacity building workshops, exchange of experiences and so forth.

3.6.4 Kenya

In Kenya, digital innovation is taking place in data management in healthcare, which has intensified during the COVID-19 pandemic. VODAN-Africa has created its own solution with the aim of providing accessible COVID-19 data by establishing an overarching network implementing the FAIR Guidelines. Kenya is one of the leading participants in this initiative. Not only does FAIR data play an important role in healthcare in Kenya, but it has the potential to improve the data ecosystem in other sectors. One example is the International Livestock Research Institute (ILRI), which has used the FAIR Guidelines to FAIRify its livestock data [49]. Although the FAIR Guidelines look straightforward, some challenges have occurred during the implementation of this project. For instance, the lack of resources has created problems in terms of data findability, whereas accessibility was not able to be provided due to the unclear roles and responsibilities of data stewards. Tools were well prepared to implement interoperability, but a lot of plans were required to make SQL databases open access. And reusability was questionable, in terms of how useful it is to make raw data available [49].

3.6.5 Zimbabwe and Uganda

Zimbabwe and Uganda are two of the main partners in VODAN-Africa. Together with VODAN-Africa's other partners, these two countries plan to make research data findable, accessible and reusable. The first machine readable FDP was installed on 22 July 2020 at Kampala International University, Uganda. This will be followed by other installations in partner universities and hospitals [50]. The successful implementation of FAIR requires three pillars [51]: (i) firstly, cultural adaptation (GO CHANGE) is required, which is defined as making the FAIR Guidelines a working standard; (ii) next, technical infrastructure is needed (GO BUILD); and, lastly, (ii) training is needed as the idea is novel and there is a lack of skilled people (GO TRAIN) [52].

Another initiative that should be mentioned here is a collaboration between a local health provider, SolidarMed, which is a non-profit association, and the Great Zimbabwe University in the Masvingo Province, Zimbabwe. This initiative aims to solve the needs of local hospitals and communities and is using the FAIR Guidelines to assess the FAIRness of systems [53].

3.6.6 South Africa

The FAIR Guidelines are also being implemented in South Africa. CODATA of the ISC works on improving the availability and usability of data for research. CODATA believes that data should be open or FAIRified in an intelligent way in order to advance data usability and interoperability [54]. Different partners are collaborating with CODATA. In South Africa, the CODATA member organisation is the National Research Foundation, which aims to improve the quality of life of all South Africans by supporting and promoting the development of new technologies and knowledge [55].

One of the projects being implemented in South Africa is AOSP, which is funded by the South African Government's Department of Science and Technology, with the collaboration of the National Research Foundation, the ISC and CODATA. This platform aims to determine the current state of data science initiatives in Africa and promote open science by increasing the number of participants using FAIR data in the global ecosystem. Policy frameworks, training and technical infrastructure are also needed for the successful operation of AOSP [56].

Trust by African communities in European innovation is limited [53]. The COVID-19 pandemic has been a catalyst for the implementation of FAIR, which has been carried forward by VODAN-Africa. VODAN-Africa has unified a number of stakeholders, including ministries of health, universities and hospitals in Uganda, Ethiopia, Nigeria, Kenya, Tunisia and Zimbabwe [57]. For example, the Great Zimbabwe University identified the VODAN project as a new generation of data and services [51] and the first FDP was installed at Kampala International University [50]. Complex challenges could be solved by the integration of diverse data resources, but the engagement of more societal actors is necessary, and the priorities of each stakeholder should be considered. With regard to FAIR implementation, Africa should adapt FAIR in its own way, according to its own societally-engaged priorities [40].

4. DISCUSSION

The results show that Kazakhstan and Russia remain in a preliminary phase of FAIR adoption, compared to Japan and Indonesia. In Russia, the focus at the moment is to introduce the FAIR concept to researchers and stakeholders in scientific data publishing. Indonesia has developed its own FAIR data equivalent system, called Satu Data Indonesia, which is led by the government. Japan is ahead in terms of the adoption of FAIR, compared to its counterparts in Asia, Kazakhstan and Russia, and has implemented FAIR in various fields such as agriculture, institutional research and citizen science.

The analysis of the literature indicates that the need for FAIR data is recognised in research data management and the healthcare sector, and that in most of the countries researched there are attempts to find a solution based on FAIR data to manage digitalised data on a large scale in a more efficient manner. Yet in Japan and Kazakhstan, central data management tends to be preferred. The reasons for this differ per the country. In Kazakhstan, data are used to a top-down approach to digital data repositories. On the other hand, concern about the legitimacy of research data and avoiding data breaches is growing in Japan and, in response, the government has launched a new data management strategy to support universities and research institutes in terms of data archives, management and queries. In Indonesia a localised FAIR equivalent called Satu Data Indonesia is being implemented. Satu Data Indonesia consists of two main strategies: better coordination among different government agencies for data production and a series of data production principles (that data must conform to data standards; metadata must be available; data must be interoperable; and a reference code must be used for data). The use of FAIR equivalent principles is also identified in Japan. For example, in Japan, the National Institute of Informatics (NII), has adopted FAIR equivalent principles since 2020 on its site GakuNin RDM (<https://rdm.nii.ac.jp>), which connects research data among Japanese academia, making it accessible and reusable. As another FAIR equivalent system, a DMP was used to maximise the value of investments in research through the reuse of publications and to guarantee data management. Unfortunately, creating DMP templates is time-consuming.

In Japan, it appears that climate is right for the adoption of FAIR data. By answering the call of the Japanese government to promote the formulation of FAIR data policies, as well as tackling the challenges identified, several stakeholders from universities, national research institutes and independent administrative agencies have explored the possibility of applying FAIR data. For example, NARO has proposed a data scheme for narolin DB, constructed by following the FAIR Guidelines. The goal is to ensure and improve the reusability, interoperability and shareability of research data by implementing metadata supported by the FAIR Guidelines. FAIR data also allows users to add customised NARO Commons metadata keywords and terminology, in addition to common metadata such as title, author name, date, keywords and location. In Indonesia, Satu Data is very similar to the FAIR Guidelines, with three out of its four principles identical to the FAIR Guidelines of Findability, Interoperability and Reusability. FAIR is, therefore, considered to be a potential tool to extend the current proposal in fields such as government data management as well as research repositories.

As to FAIR implementation in Africa and the Middle East, the analysis indicates that there is also a window of opportunity open. Specifically, there is a demand for a research data management system to be built for data sharing among Arab researchers, and the FAIR Guidelines are seen as a solution to fill the gap created by the lack of a DMP, as an important step in the research lifecycle for scientists in the Middle East. Although there is a lack of details on FAIR implementation in general, cooperation between Middle East and the West has been established. For example, a data management system called 'Lesionia' was built based on FAIR data, and the project ROMOR not only launched a series of summer school courses to help train junior scientists, support service staff, and librarians on how to apply FAIR data to research data related to accessibility, interoperability and reusability, but also focused on constructing OAIRs that aggregate and enable access to the collective Palestinian research data.

In addition, FAIR data is suggested as a feasible solution to healthcare data management and environmental issues on the African continent. There are three main projects, namely: AOSP, CODATA and VODAN-Africa, all based on FAIR data, although carried out through different channels, on a regional or country level, with different stakeholders. AOSP has been defined as supporting open science, while CODATA and VODAN-Africa aim to optimise health data management to protect people from the impact of COVID-19. On a regional level, the Digital REACH Initiative and East Africa Open Science Cloud for Health have been organised to improve the general health of local citizens in East Africa by introducing a real-time digital health platform, in which FAIR data is used to enhance the reusability and shareability of health data in the community. As to specific African countries, the main participants of the VODAN-Africa project are Uganda, Ethiopia, Kenya, Nigeria, Somalia, Tanzania, Tunisia and Zimbabwe. South Africa plays an important role in bridging AOSP and CODATA. Like in Japan and Indonesia, the implementation of FAIR equivalent systems is found in Egypt and Tunisia. Research data repositories are included on re3data.org, namely: Egypt's Information Portal and the African Development Bank's statistical data portal Open Data for Africa. The purpose of both repositories is to increase the shareability of data in a real-time manner and to promote local open science.

In conclusion, a window of opportunity for implementing the FAIR Guidelines is open in Asia, Africa and the Middle East, confirming the feasibility of FAIR Guidelines, however, more awareness needs to be raised in Russia and Kazakhstan about the benefits of FAIR to ensure that it is firmly on the policy agenda.

5. CONCLUSION AND FUTURE WORK

This study conducted a systematic literature review and analysis regarding the implementation of FAIR-data in non-Western geographies (Africa, Indonesia, Japan, Kazakhstan, Russia and the Middle East). It found that windows of opportunity are open in most of the non-Western countries investigated with regard to the implementation of the FAIR Guidelines, however, to different degrees. Four different levels can be identified: At the first level, the FAIR Guidelines have been discussed, but more effort needs to be made to raise awareness of the problem and benefits of the solution to place it on the policy agenda (e.g., Kazakhstan, Russia, countries in the Middle East, some countries in Africa). At the second level, FAIR equivalent systems

have been implemented, such as Satu Data Indonesia. This system mainly serves as a bridge among different governmental agencies in Indonesia, and data interoperability is restricted to within the local context. More observations are needed about the use of this FAIR equivalent system in Indonesia. Many African countries are currently at the third level, that is, they are in the process of adopting the FAIR Guidelines, although at different stages. Lastly, Japan is at the fourth level, as it has not only implemented FAIR equivalent systems, such as GakuNin RDM, but also created localised systems based on the FAIR Guidelines, such as narolin DB. The implementation and interoperability of such systems in a global context of data interaction needs to be considered in the future.

AUTHORS CONTRIBUTION STATEMENT

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ACKNOWLEDGEMENTS

We would like to thank Misha Stocker for managing and coordinating this Special Issue (Volume 4) and Susan Sellars for copyediting and proofreading. We would also like to acknowledge VODAN-Africa, the Philips Foundation, the Dutch Development Bank FMO, CORDAID, and the GO FAIR Foundation for supporting this research. Lastly, we would like to give a special thanks to Prof. Dr Mirjam van Reisen, for being the editor of this Special Issue.

CONFLICT OF INTEREST

All of the authors declare that they have no competing interests.

ETHICS STATEMENT

Tilburg University, Research Ethics and Data Management Committee of Tilburg School of Humanities and Digital Sciences REDC#2020/013, June 1, 2020-May 31, 2024 on Social Dynamics of Digital Innovation in remote non-western communities

Uganda National Council for Science and Technology, Reference IS18ES, July 23, 2019-July 23, 2023

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APPENDIX 1. SEARCH STRATEGY

Search strategy (CiNii, J-Global, researchmap.jp, yahoo.co.jp, google scholar, baidu.com, yandex.ru)

((findable OR findability) AND (accessible OR accessibility) AND (interoperable OR interoperability) AND (reusable OR reusability)) OR (FAIR AND (Asia OR Africa OR Arab OR Indonesia OR Japan OR Kazakhstan OR Russia)) OR FAIR) AND (data OR データ OR تاناييبل OR деректер OR данные)

Search range by year: 2014–2021

APPENDIX 2. NON-WESTERN PUBLICATIONS

Author	Year	Title	English title	Publisher
Ikeuchi Ui	2018	データマネジメントプラン（DMP: FAIR原則の実現に向けた新たな展開（連載：オープンサイエンスのいま）	Data management plan (DMP): New dimension to implement FAIR Guidelines	Information Science and Technology Association
Ikeuchi Ui	2019	研究データ管理（RDM）の目的地と現在地	Current trend of open science: Research data management (RDM)—goals and strategy	Information Science and Technology Association
Masao Mori, Tetsuya Oishi	2019	大学 IR 情報の流通における質保証について	Quality assurance regarding the distribution of university IR information	Japan Society of Educational Information
Takahiro Kawamura	2020	農業研究データ基盤研究に向けた総合データベース構築	NARO Linked database for agricultural research data management	Japanese Society for Artificial Intelligence
Council for Science, Technology and Innovation	2019	国立研究開発法人におけるデータポリシー策定のためのガイドライン	Guidelines of Data Policies at National Research and Development Institutes	Ministry of Health, Labour and Welfare
Арте́м Баля́кин, Андре́й Ма́лышев	2020	Управление большими данными в исследовательских инфраструктурах	Big data management in research infrastructures	Издательство «Открытые Системы»
Ши́шаев Макси́м Генна́дьевич ¹ , Ви́центий Алекса́ндр Влади́мирович ¹ , Ку́приков Ники́та Миха́йлович	2019	Концепция национальной системы управления данными: современный контекст реализации	Concept of a national data management system: Modern implementation context	Труды Кольского Научного Центра РАН (Кольский научный центр Российской академии наук (Апатиты))
Н.С. Редькина	2019	Подготовка библиотекарей в области управления исследовательскими данными	Teaching of librarians' skills in research data management	Ученые записки (Алтайская Государственная Академия Культуры и Искусств)

Implementation of FAIR Guidelines in Selected Non-Western Geographies

Author	Year	Title	English title	Publisher
И. Юдина, О. Федотова	2020	Технологии информационного общества. Репозитории научных публикаций открытого доступа: история и перспективы развития	Information society technologies: Open access scientific publications repositories: History and development prospects	Журнал Информационное Общество
