Quality of Scientific Production Validation of Research Traceability Standars

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Without a specific standard for evaluating the quality of research output, funding agencies and academic journals have placed a growing emphasis on implementing study monitoring procedures. Within this context, this study validated research traceability standards that can contribute to improving the quality of scientific production. A qualitative study was conducted with a community of researchers to identify and validate traceability standards to ensure scientific research quality. Ten standards related to scientific traceability and reproducibility were identified, with particular emphasis on the description of methodology and data sharing, which emerged as the most relevant.

Keywords: Scientific Research. Quality. Traceability.

Scientific research is essential for societal advancement, providing a foundation for in-depth exploration of phenomena based on their inherent characteristics and modes of operation [1]. The scientific community broadly acknowledges that rigorous methods and reliable results are indispensable for research integrity and scientific knowledge advancement. Notably, nearly 30% of article retractions are attributed to scientific error or the inability to verify results, which may only represent a fraction of the broader issue [2]. This scenario poses particular risks in an environment increasingly reliant on external funding, while suffering from a shortage of human resources and stable research infrastructure. As such, the reliability of scientific data is paramount—not only for the progression of science, but also for maintaining the trust of the public and collaborators within research teams. Individual scientists and institutions are responsible for the quality and integrity of the research they produce and disseminate [3].

In recent years, quality management within the Research and Development (R&D) sector has become increasingly critical, driven by the growing demand for researchers to demonstrate adherence to the highest methodological standards. Implementing quality management criteria, particularly those related to scientific traceability, facilitates impartial monitoring and verification across all domains of research and development. Although no universal standards for research quality currently exist, relevant quality criteria from established standards and manuals should be adapted and applied wherever feasible to ensure data compliance [4]. In this context, the application of quality principles—such as data traceability—proves to be highly beneficial, reinforcing the positive intersection between Quality Management and scientific research.

This study aimed to identify and validate scientific traceability standards, thereby contributing valuable insights to the scientific literature. The objective was to enhance the transparency and reproducibility of the research process by establishing clear standards that other investigators can adopt and replicate.

Materials and Methods

This qualitative study was conducted in two stages. Figure 1 illustrates the process for validating the identified criteria.

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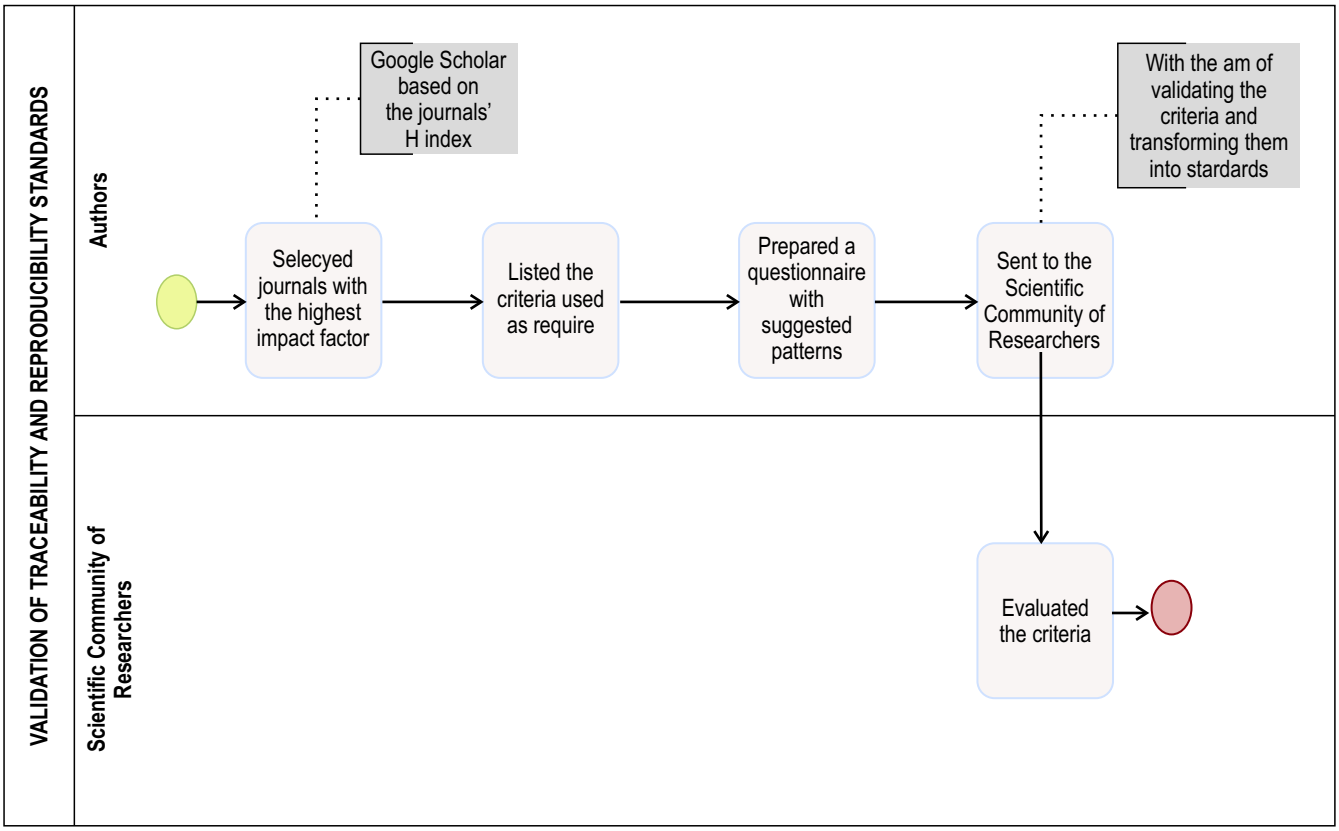
Figure 1. Diagram of the standards validation steps.



In the first phase, the journals with the highest impact factor in January 2023 were selected, they were: Nature, The New England Journal of Medicine, Science, IEEE/CVF Conference on Computer Vision and Pattern Recognition and The Lancet with H5 indexes of 444, 432, 401, 389 and 354, respectively [5]. The criteria for publication in these journals related to traceability and reproducibility were evaluated and described in Table 1—the criteria for publication in these journals related to traceability and reproducibility

In the second phase, the selected criteria were sent to a scientific community of researchers, in person or remotely, and answered by 31 researchers from the Oswaldo Cruz Foundation, a health research institution of the Brazilian Government with relevant scientific production. The researchers were randomly assigned and responded to the questionnaire using the criteria listed in Table 1.

The researchers who participated in the study assigned percentage values to each traceability criterion, reflecting the relative importance of each standard compared to the others. The total of all assigned percentages equaled 100%, ensuring a balanced assessment. The data were organized and analyzed according to the value attributed to each standard by the participants, based on perceived importance. The study complied with ethical standards, having been approved by the Federal Institute of Bahia Research Ethics Committee under opinion number 079685/2022.

Results and Discussion

Traceability refers to the ability to map and follow the entire pathway of a process, from its initial stages to its conclusion. In the research context, this implies monitoring the investigative process from conception to final output. With the

Table 1. Criteria related to traceability and reproducibility evaluated by the scientific community.

Criteria related to the traceability and reproducibility evaluated by the scientific community		
1	**Method**	Description of the methodology used
2	**Material (Equipment and Reagents)**	
3	**Artifacts (Collection instruments)**	
4	**Dataset (What data was used)**	Sharing and making data and/or codes available
5	**Where data is stored/can be found**	
6	**Peer review**	Other criteria
7	**Presence of bibliographic references**	
8	**Technical terms used in scientific research**	
9	**Indication of software, equipment or tools used**	
10	**Availability of results**	

rapid advancement of technological innovation, growing competitiveness, and increasing pressure for productivity, quality assurance tends to be overlooked in scientific research and publication [6].

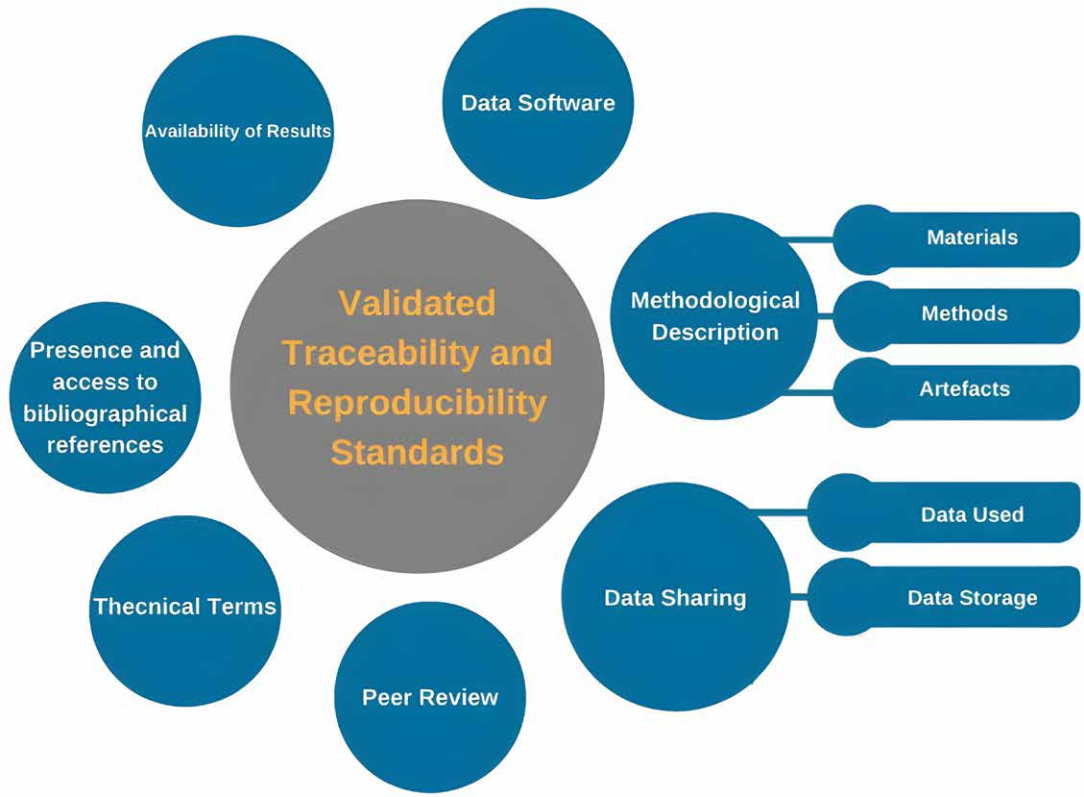
Recognizing the importance of traceability necessitates a broader reflection on the foundations of science. Science must be grounded in the capacity to critically evaluate conclusions drawn by researchers, particularly those that have exerted or may exert significant influence. In this regard, ensuring traceability is indispensable for confirming or revising findings. Achieving this requires transparency in data and full disclosure of the methods employed in generating it. Clear, intelligible, and traceable documentation—including detailed accounts of data acquisition processes and any subsequent modifications—is essential both during the research and after publication [7].

Moreover, research findings that lack traceability tend to be less reliable and less valuable. Methodological approaches that systematically pursue predictive statistical models through trial-and-error steps often fail to report unsuccessful attempts, which may also hold scientific value. The omission of such results, simply because they did not meet the researcher's expectations, undermines the study's reproducibility and replicability. This practice contributes to a body of irreproducible findings that ultimately threaten scientific disciplines' credibility, utility, and foundational principles [8].

At the conclusion of the second phase of this study, the scientific community engaged in the research validated a set of traceability and reproducibility standards. These validated criteria are presented as formal traceability standards, as shown in Figure 2.

For the scientific community surveyed, the standards presented in Figure 2 were deemed critical for ensuring research quality.The standard most strongly associated with methodology encompasses the parameters, procedures, rules, and/or techniques, including computational approaches, used to construct and explain

Figure 2. Validated traceability and reproducibility standards.



knowledge generation [9]This standard was further subdivided into:

i) Materials – the resources employed in the research, including equipment, instruments, and biological or chemical products;
ii) Method – the approach used to conduct the study or experiment, including the procedures adopted to obtain results;
iii) Collection artifacts or instruments – objects created explicitly for the study, such as design products, prototypes, or software.

The second key standard, data sharing, is fundamental to timely disseminating studies, knowledge, and new lines of inquiry, thereby accelerating scientific discovery. It also enables the reuse and validation of previously generated data for future research efforts [10]. This standard was subdivided into:

iv) What data was used – a description of the datasets included in the research;
v) Where the data can be found – information on how to access the data, including files, systems, or repositories used in the study.
vi) The sixth standard, results availability, ensures that quality-assured data associated with the study's findings are accessible [11].
vii) Bibliographic references – this standard supports the validation of the research and situates the study within the broader context of existing literature. This facilitates a deeper understanding of the subject matter and allows readers to expand their knowledge of the topic [11].
viii) Technical terms or vocabulary help to identify key concepts and ideas presented in the study, improving clarity and efficiency in reading. This standard establishes a shared language to precisely convey concepts related to the research theme [11].
ix) Software or tools refers to digital programs used throughout the research and publication

process, including those for document creation, image editing, data analysis, and more.

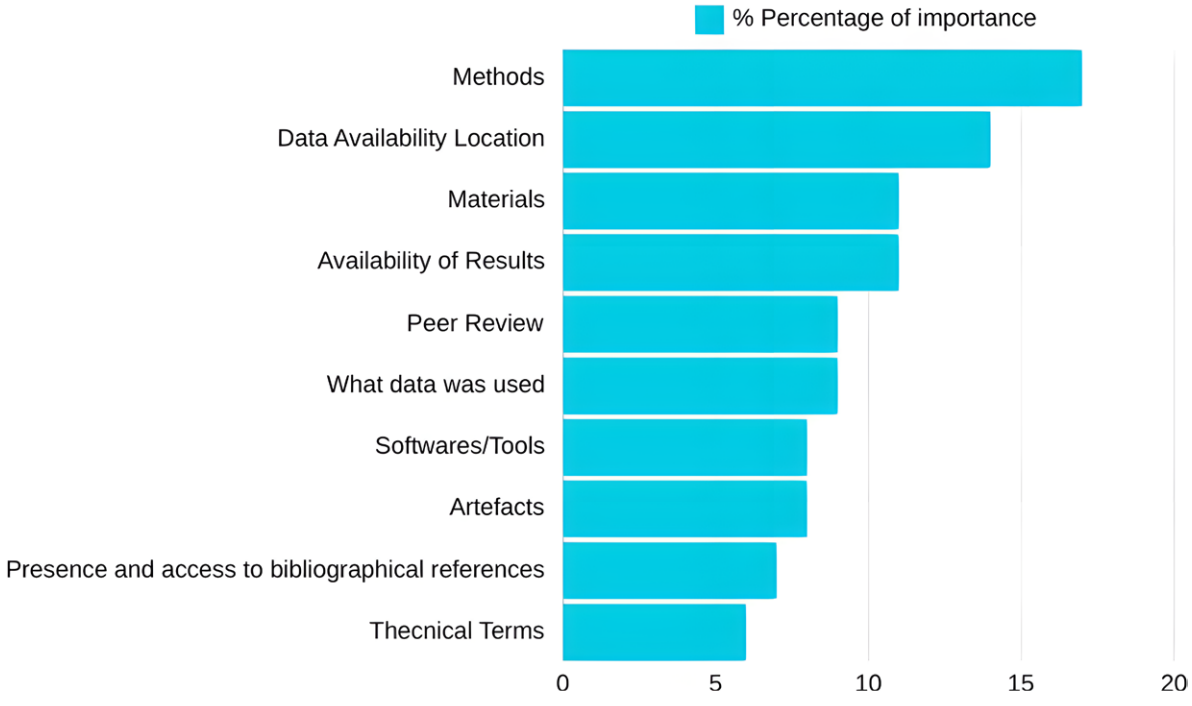
x) The standard peer review is widely recognized as a collaborative and essential component of scientific publishing. It involves submitting research for evaluation by domain experts to verify scientific validity and uphold rigorous quality standards, ultimately ensuring that only robust and credible research is published [12].

Together, these results enabled the identification of a comprehensive set of criteria—previously uncodified as a unified framework—proposed as a potential scientific standard for traceability and reproducibility. Furthermore, the consultation with researchers allowed the assignment of relative importance to each criterion, as illustrated in Figure 3.

The standards related to methods—materials, method, and artifacts—were assigned relative importance scores of 11%, 17%, and 8%, respectively, totaling 36% for the methodology standard. Among these, the method component stood out with 17%, underscoring the significance of establishing efficient and well-structured research methods. The criteria associated with data used and data accessibility received scores of 9% and 14%, respectively, up to 23% for the data sharing standard, which was identified as the second most critical domain.

The remaining standards—peer review, references, technical vocabulary, software/tools, and results availability—were rated at 9%, 7%, 6%, 8%, and 11%, respectively. These results demonstrate that, from the respondents' perspective, the methodology and data sharing standards are the most significant for ensuring the quality of scientific research. Scientific research must continually aim to generate meaningful and valuable knowledge for society, offering explanations of facts and phenomena aligned with the public and social interest. The dynamic nature of knowledge construction necessitates regularly updating

Figure 3. Criterion x Importance.



scientific understanding [13,14]. Within this context, researchers, scientists, research institutions, and universities play a vital role in producing scientific outputs. Applying traceability standards effectively communicates the critical rigor required for scientific credibility and reliability to the broader society.

Conclusion

Concerns regarding scientific research quality, integrity, and usefulness are becoming increasingly visible. They must be addressed not only by individual researchers but also by institutional managers and all stakeholders involved in producing and disseminating scientific knowledge. Scientific outputs must ensure the generation of credible, verifiable information to support sound decision-making, thereby offering tangible value to society through high-quality research.

The absence of traceability and reproducibility presents potential risks, particularly when viewed through good research practices. Conversely, re-evaluating data in light of enhanced transparency can significantly contribute to scientific rigor and quality improvement.

This study identified and validated ten traceability and reproducibility standards that authors and journals can adopt to improve the clarity, accountability, and repeatability. While all ten standards were acknowledged, the methodology and data sharing standards emerged as the most relevant according to the researchers surveyed. These findings suggest the need for further investigation into the specific reasons for the perceived prominence of these standards and the identification of minimum essential parameters necessary to ensure their effective implementation in scientific research workflows.

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