RESEARCH & PUBLICATION ETHICS

A COMPLETE GUIDE TO CONDUCTING & PUBLISHING RESEARCH ETHICALLY

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Dear reader,

The topic of research ethics is important not only when conducting research but also when publishing it. It is one of the crucial pillars for maintaining scientific integrity and credibility. The onus to implement fair practices lies with researchers, universities/institutions, and publishers.

Through this ebook, we intend to provide a concise yet comprehensive resource to graduate students and early-stage researchers. We have identified common areas where researchers often face doubts and challenges. We have shared insights on popular topics such as how to assign authorship, how to avoid image manipulation and plagiarism, how to manage research data effectively, or how to identify conflicts of interests. This ebook will provide you with ample tips for effectively handling all such situations.

Towards the end, you will also find a list of authentic e-resources. It would be our pleasure to help you with your publishing requirements. Please make it a point to visit enago.com/academy for further help. We have posted 1,000+ original articles on this knowledge e-platform.

Happy reading!

Regards,
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TABLE OF CONTENTS

Research Ethics....4

Research Ethics & Its Importance....5

Codes & Policies....8

Codes & Policymakers....9

International Ethics Codes....10

Conducting & Publishing Research Ethically....12

Protection of Human Subjects....13

Care of Laboratory Animals....15

Handling Conflicts of Interest....17

Managing Research Data....19

Assigning Authorship....21

Avoiding Plagiarism....24

Publishing Research Ethically....26

Research Misconduct....28

What is Research Misconduct?....29

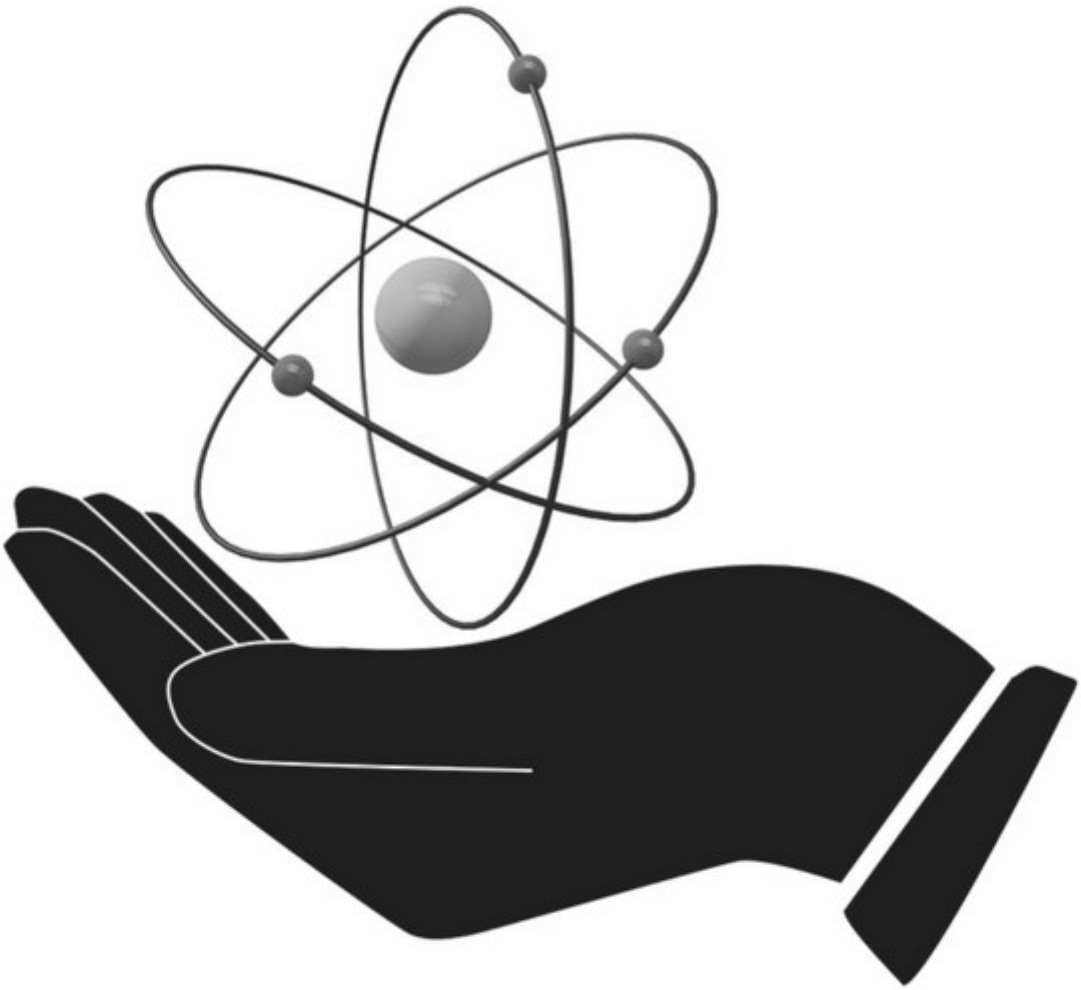
Image Manipulation....30

Research Reproducibility....31

References....32

Free Author Resources....33

1. RESEARCH ETHICS



RESEARCH ETHICS & ITS IMPORTANCE

What is ethical conduct of research? You may have often heard the term "ethics." It is generally defined as a set of principles that distinguish between acceptable and unacceptable behavior or way of conducting a task. These guidelines or principles may vary across countries, disciplines, institutions, and even laboratories. For instance, these ethics may not only dictate the conduct and functioning of an organization or a government but also a business entity! Do you know which codes you should follow when conducting your research?

One of the most commonly known ethical code in medical practice, the "Hippocratic Oath," dates back to 500 B.C. [1]. Over the years, guidelines such as Nuremberg Code and Declaration of Helsinki have been introduced and implemented into practice. Moreover, ethical policies addressing issues related to plagiarism, fabrication, conflicts of interest etc. are being outlined at different governmental and academic levels. Refer to the ethics timeline below for a detailed overview [2].

Why is it important for you as a researcher to follow these ethical codes? How does adherence to these can impact your credibility and repute in the scientific community?

Firstly, these ethical codes not only help maintain scientific integrity but also safeguard the primary aim of conducting the research i.e. to promote knowledge and truth [3]. Secondly, these values promote trust, respect, and objectivity in a collaborative work environment by avoiding conflicts related to authorship, copyrights, and others [3]. Moreover, these codes help maintain the safety and interest of human subjects and ensure appropriate care of animal subjects in a clinical or laboratory setting [3]. Lastly, these ethical norms make researchers accountable for the quality and outcome of the research that may directly or indirectly affect public health and interests [3].

Research Ethics Timeline

1932—1972

The Tuskegee Syphilis Study sponsored by U.S. Dept. of Health observed the effect of untreated Syphilis in 400 African men. The patients were uninformed about the experiment and researchers withheld the penicillin treatment.

1939—45

German scientists conducted research on concentration camp prisoners.

1944—1980s

The U.S. government sponsored research on effects of radiation on uninformed subjects including cancer patients, pregnant women, and military personnel.

1947

The Nuremberg Code for research on human subjects was introduced.

1953

James Watson and Francis Crick discovered the structure of DNA after secretly obtaining diffraction data from Rosalind Franklin without her permission.

1964

The World Medical Association developed Declaration of Helsinki as a statement of ethical principles for medical research involving human subjects.

1960s /1970s

Animal protection laws adopted following animal rights movement.

1966

Henry Beecher exposed 22 unethical studies in an article in *N. Engl. J. Med.* that included the Tuskegee syphilis study and the Willowbrook hepatitis study. The first Research Ethics Committee (REC) appeared in the UK.

1979

]The Belmont Report was released that became a milestone in human research ethics regulation in the U.S.

1989

NIH mandates responsible conduct of research education be imparted to graduate students receiving training grants.

2001

European Union's Directive 2001/20/EC came into existence.

Journals such as *Nature* and *JAMA* aksed authors to define their responsibilities when publishing research.

2010

NSF introduced responsible conduct of research (RCR) training for students, investigators, and trainees.

The Lancet retracted a fraudulent a paper by Andrew Wakefield, linking autism to the measles vaccine.

2013

NIH and NSF revised conflict of interest guidelines for funded research.

2014

Nature retracted two high-profile papers on pluripotent stem cells by Haruko Obokata on the grounds of fabricated and falsified data.

Many journals including *Science* and *Nature*, and funding agencies such as NIH took steps to advance reproducibility in Science.

2016

NIH placed a temporary ban on experiments involving human-animal chimeras.

2017

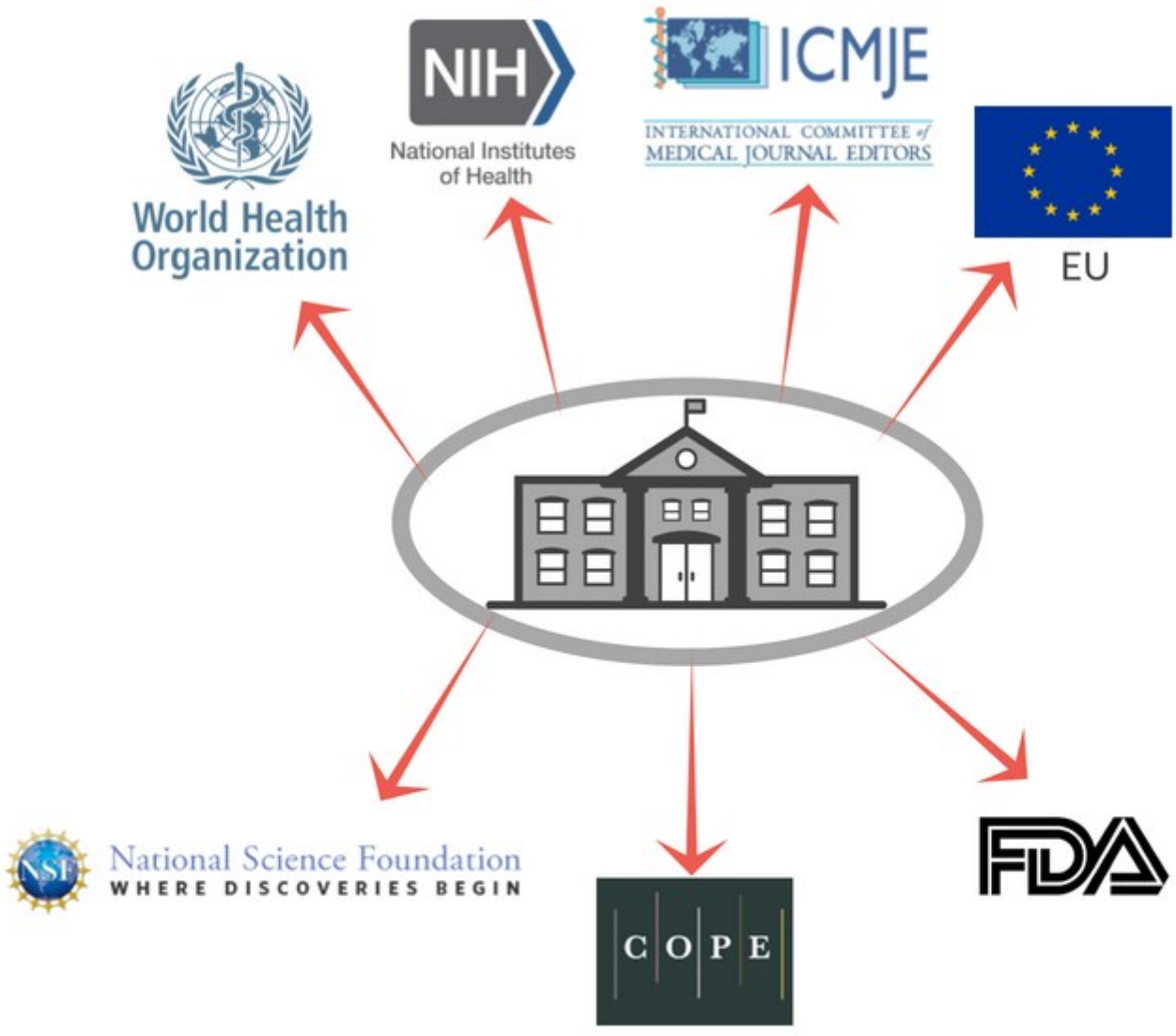
Seventeen federal agencies published the Final Rule that eliminated the controversial rules of requiring prior consent for all research involving human biological samples.

2. CODES & POLICIES

CODES AND POLICYMAKERS

Various organizations have played an instrumental role in the development and adoption of the ethical guidelines across universities, funding agencies, publishers, and institutions. Some of the prominent names are listed below. Moreover, universities and research institutes set up an independent administrative entity called ethical committee (EC) or an institutional review board (IRB).

This body is mainly responsible for protecting the rights and welfare of human subjects involved in clinical studies. IRBs and ECs oversee any clinical trial or biomedical research [4]. These entities not only review the protocol but also ensure compliance with the required ethical codes, thereby minimizing any risk to the subjects involved.



INTERNATIONAL ETHICS CODES

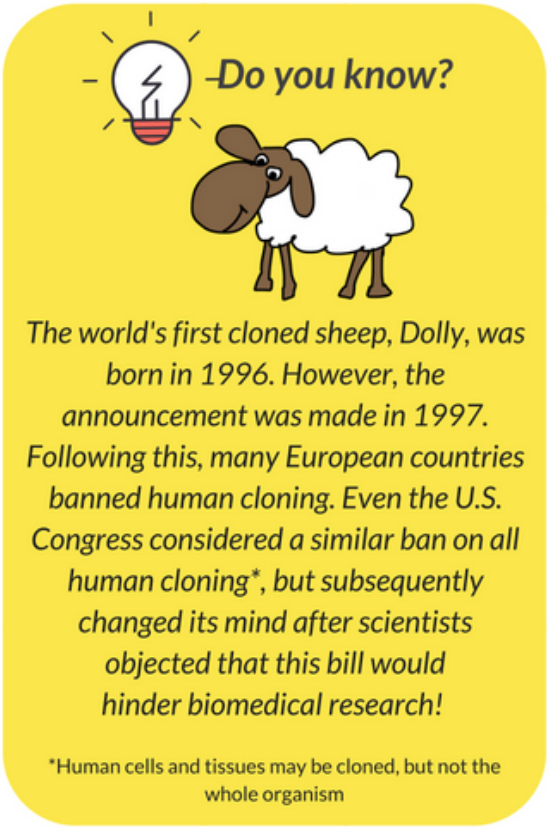
Few of the international codes and policies [2, 3] include:

- *Code of Ethics* from the International Sociological Association
- *Universal Declaration on Bioethics and Human Rights* from UNESCO
- *International Ethical Guidelines for Biomedical Research Involving Human Subjects* from the Council for International Organizations of Medical Sciences (CIOMS)
- *Declaration of Helsinki* from the World Medical Association
- *Nuremberg Code*
- *The Chemical Professional's Code of Conduct* from the American Chemical Society
- *Singapore Statement on Research Integrity*
- *ICH Guidelines* from The International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use

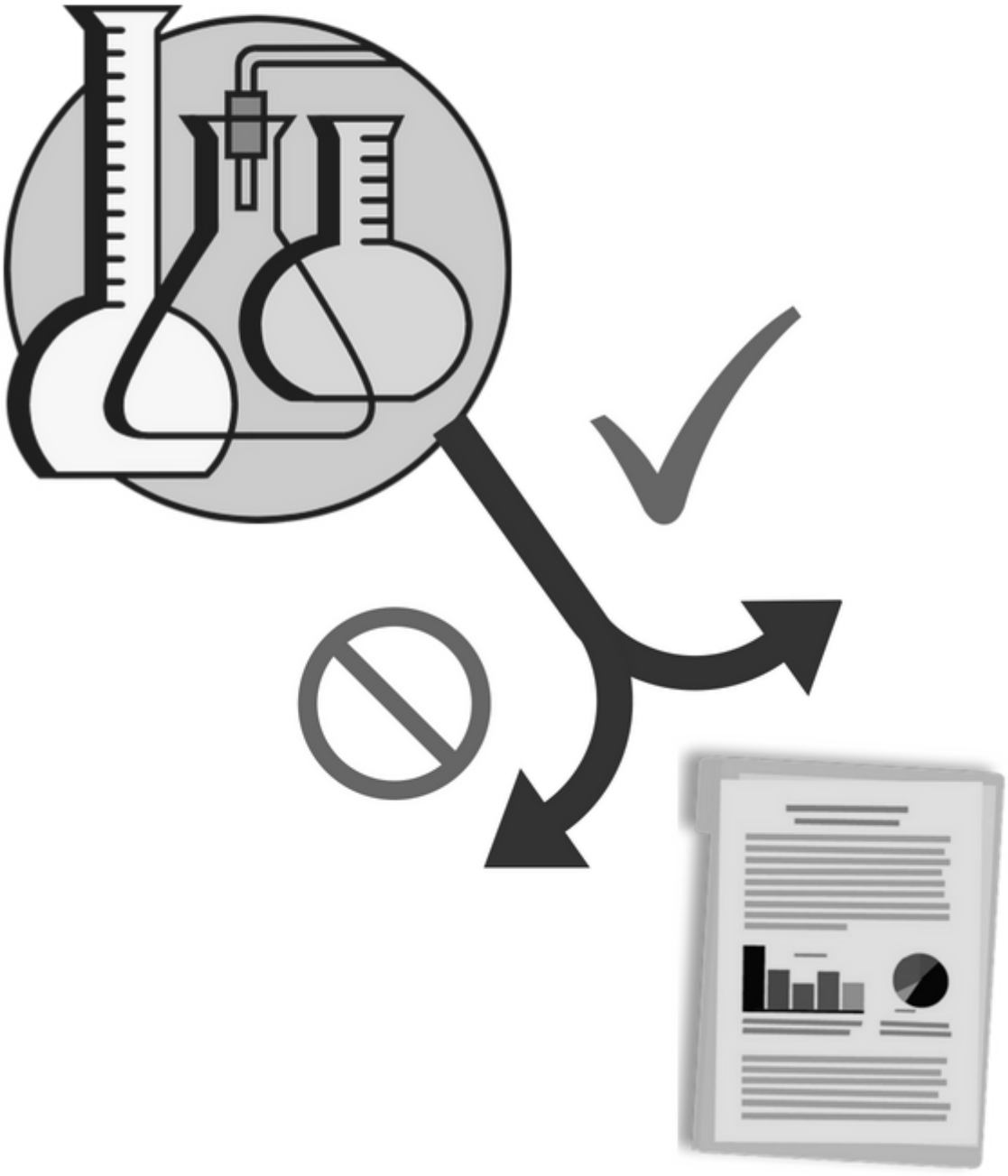
Shamoo and Resnik have effectively summarized the important ethical requirements for researchers [2]:

- *Integrity*: Fulfil your promises and obligations of your agreements. Show sincerity and consistency in your actions and thoughts.
- *Honesty*: Communicate and report your research data, results, methods, procedures, and publication status honestly. Strictly avoid falsification, fabrication, and misrepresentation of research output.
- *Objectivity*: Avoid bias in experiment/ study design, data analysis, data interpretation, peer review, personnel decisions, and grant writing. Disclose both personal and financial interests.
- *Competence*: Strive to improve your expertise and take effective steps to advance competence in your field.
- *Carefulness*: Maintain a good record of your research activities including data collection and correspondences with journals. Examine your work thoroughly with peers to avoid errors.
- *Openness*: Share your data, results, tools, resources, and ideas.
- *Legality*: Adhere to required governmental and institutional laws/policies.

- *Confidentiality*: Maintain confidentiality of important information such as patient records, trade or military secrets, grant applications, and papers submitted for publication.
- *Non-discrimination*: Avoid discrimination against colleagues or students based on gender, sex, ethnicity, race, or religion.
- *Respect for Intellectual Property*: Do not use published or unpublished material without permission. Avoid plagiarism! Acknowledge and credit the original author/creator. Follow obligations related to a patent, copyright, trademark, and more.
- *Responsible Publication*: Avoid duplicate publication. Follow publication ethics to advance science and not just your career.
- *Responsible Mentoring*: Encourage, educate, mentor, and advise students.
- *Social Responsibility*: Advocate and advance public interests and health through your research.
- *Animal Care*: Show respect and care for animals in a study by avoiding bad study designs and experiments.
- *Human Subjects Protection*: Maintain respect, confidentiality, welfare, and dignity of human subjects involved in clinical studies. Minimize any risk/harm to the study population.



3. CONDUCTING & PUBLISHING RESEARCH ETHICALLY



PROTECTION OF HUMAN SUBJECTS

Research studies involving human subjects contribute to the advancement of medical and health sciences. Such studies provide insightful data on safety and efficacy of new lines of treatments, therapies, drugs, or devices. However, the involvement of human subjects does increase the risk and harm to the subjects. Therefore, clinical studies are highly scrutinized and regulated.

Researchers should not only follow relevant international guidelines but also abide by the local or state regulations for protection and welfare of the human subjects. For instance, in the U.S., Title 45 of the Code of Federal Regulations, Part 46 (45 CFR 46) from Health and Human Services (HHS) and 21 CFR 50 and 56 from FDA, define rules for human subjects research [5].

There are effectively two types of clinical studies [6].

- Intervention studies/clinical trials
- Observational studies

Moreover, different standard guidelines (e.g., CONSORT, STROBE, PRISMA, etc.) do exist for designing, conducting, and reporting intervention and observational studies.

A resource on health research, called Enhancing the QUAlity and Transparency Of health Research (EQUATOR) provides the most recent information on study designs and reporting standards for researchers and clinicians [7].

For a detailed overview of these statements, refer to the table below.

Most journals require authors to register clinical trials prior to publishing research in public clinical trial registries such as ClinicalTrials.gov, ISRCTN registry, and EU Clinical Trials Register [8]. The journals also encourage authors to submit statements indicating that international guidelines and best practices were followed in these trials.

In addition, statements mentioning that appropriate clearances were taken from research ethics committees or institutional review boards before the conduct of the trials are also required. Journals, therefore, have the right to reject manuscripts that do not follow the required guidelines [9].

Study Types	Reporting Standard	Website
Randomized trials	Consolidated Standards Of Reporting Trials (CONSORT)	www.consort-statement.org
Observational Studies	Strengthening the Reporting of Observational studies in Epidemiology (STROBE)	www.strobe-statement.org
Systematic Reviews	Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)	www.prisma-statement.org
Case Reports	Consensus-based Clinical Case Reporting Guideline Development (CARE)	www.care-statement.org
Qualitative Research	Standards for Reporting Qualitative Research (SRQR) & Consolidated criteria for reporting qualitative research (COREQ)	
Quality Improvement Studies	Standards for Quality Improvement Reporting Excellence (SQUIRE)	www.squire-statement.org
Economic Evaluations	Consolidated Health Economic Evaluation Reporting Standards (CHEERS)	
Study Protocols	Standard Protocol Items: Recommendations for Interventional Trials (SPIRIT)	www.spirit-statement.org
Clinical Practice Guidelines	Appraisal of Guidelines for Research & Evaluation (AGREE)	www.agreetrust.org

CARE OF LABORATORY ANIMALS

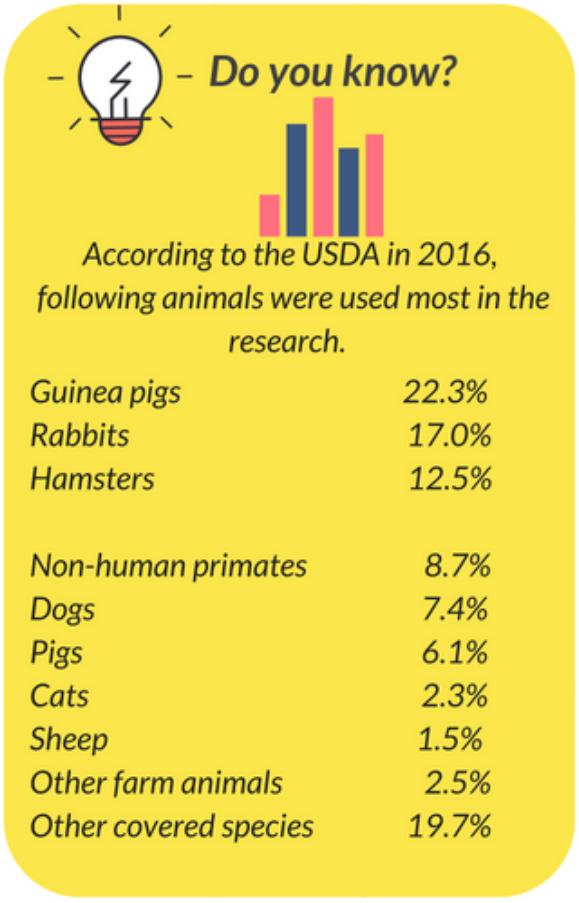
Studies involving laboratory animals have provided insights into the development of new vaccines and drugs. Unlike human subjects, laboratory animals cannot give informed consent and therefore, the care and use of animal subjects in a study warrant attention from researchers.

An Institutional Animal Care and Use Committee (IACUC) in universities or institutes ensures that appropriate procedures and study protocols are followed for the welfare and humane treatment of all the animal subjects.

Kilkenny et al. laid out extensive guidelines, called ARRIVE (Animal Research: Reporting of In Vivo Experiments) to improve the reporting of studies involving animals [10]. It is a 20-point checklist that is used when submitting manuscripts that outlines or describes animal research.

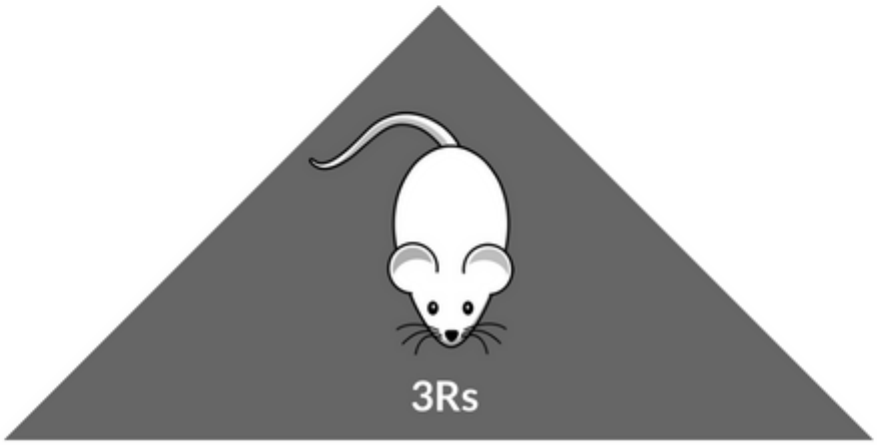
Moreover, the principles of the 3Rs (Replacement, Reduction, and Refinement) proposed by Russell and Burch more than 50 years ago have now been globally accepted and implemented. Refer to the figure below for a detailed overview of these principles [11].

In addition, the National Institute of Health (NIH) Office of Laboratory Animal Welfare (OLAW) provides extensive resources on policies and guidelines on the use of animals. The journals require authors to submit documents to indicate whether institutional or national guidelines for animal subjects were followed and whether approval was taken from the relevant ethics committees. Many journals reserve the right to reject manuscripts if these requirements are not followed.



Accelerating the development and use of models and tools, based on the latest science and technologies, to address important scientific questions without the use of animals

Methods that recommend avoiding or replacing the use of animals



Methods that minimise the number of animals used per experiment

Appropriately designed and analyzed animal experiments that are robust and reproducible, and truly add to the knowledge base

Methods that minimise animal suffering and improve welfare

Advancing research into animal welfare by exploiting the latest in vivo technologies and by improving the understanding of the impact of welfare on scientific outcomes

HANDLING CONFLICTS OF INTEREST

The changing dynamics of research environment and collaborations can often give rise to conflicts of interests and commitments/obligations. Therefore, it is important to maintain transparency in research and publication by both authors and publishers.

What constitutes conflicts of interest? For instance, conflicts of interest can arise when a researcher who is heading the research of a product is also a visiting consultant at the parent company. Conflicts of interest can also arise when an author, researcher, editor, or a peer reviewer has a relationship (personal or financial) that can directly or indirectly affect his/her objectivity in making decisions or influence his/her actions [12, 13].

Conflicts of interests [12, 13] can arise because of the following:

- Financial relationships: These can include direct employment, consultancies to a related organization/company, stock options, grants, patents, and paid expert testimony.
- Personal relationships: These can include rivalries and bias.
- Intellectual beliefs: These can include moral convictions or personal beliefs that can influence scientific opinions.
- Academic competition: It can include biased judgements because of the direct or indirect competition with peers or colleagues.

Such situations are sometimes unavoidable and finding yourself in such a situation itself is not unethical [12]. Therefore, all the stakeholders, including authors, editors, and reviewers must maintain transparency and disclose all potential or actual conflicts of interest.

So, what is your responsibility as an author in reporting and managing conflicts of interest? The Office of Research Integrity (ORI) suggests that to manage or remove conflicts of interest, take the following steps [5].

- Disclose all interests so that the stakeholders are aware and can take the required steps.
- Monitor research and research results for transparency and integrity.
- Remove the person in question from important processes such as data interpretation or review process.

As an author, make sure you follow the guidelines described below (Ref.: International Committee of Medical Journal Editors (ICMJE)).

Submitted Work

Received funds or services from an outside party/organization (any government, private, or commercial entity) for your submitted work (grants, data monitoring, study design, manuscript preparation, statistical analysis, etc.)

If yes, then disclose and state the potential conflicts of interest when submitting your manuscript.

Financial Interests/Gains

Have financial relationships with entities such as government agency, foundation, commercial sponsor, academic institution, etc. that are related to the study (directly or indirectly)

If yes, then disclose the sources of funding for your work including all sponsors and role of those sponsors in study design, data collection, data analysis, data interpretation, writing and submitting of the manuscript/report etc. If there was no such involvement from the sources, you can provide a statement stating the same.

Intellectual Property

Have planned, pending, or issued patents relevant to the work

If yes, then disclose and state the potential conflicts of interest when submitting your manuscript.

Other Relationships

Have any relationships or carried out activities that readers of the manuscript can potentially perceive to have influenced the ideas/work presented in your work.

If yes, then disclose and state the potential conflicts of interest when submitting your manuscript.

"Editors may request that authors of a study sponsored by a funder with a proprietary or financial interest in the outcome sign a statement, such as 'I had full access to all of the data in this study and I take complete responsibility for the integrity of the data and the accuracy of the data analysis.'" [13]

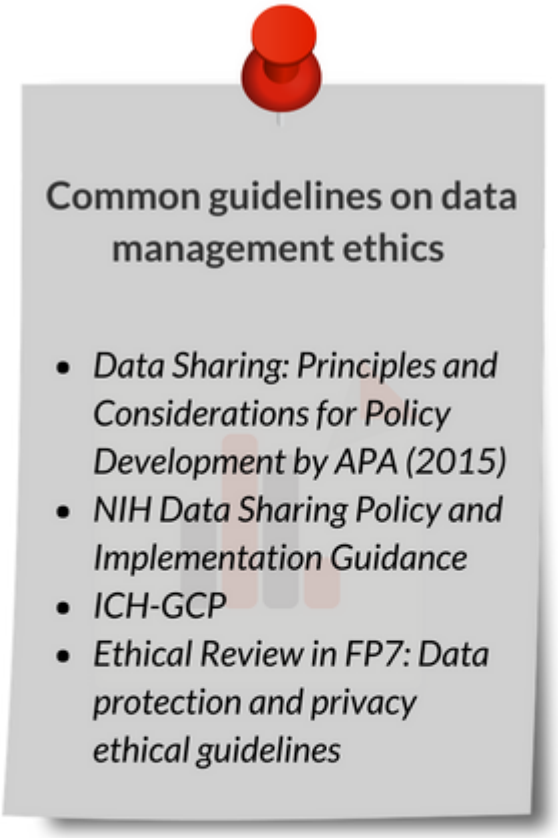
MANAGING RESEARCH DATA

Data are important outputs of a research process. These can be used to accept or reject a hypothesis or frame a new hypothesis. Data management, therefore, is crucial during and even after the research [5]. It can include the following aspects.

- Data ownership: It implies ownership of the legal rights to the research data during and after the research project. The important stakeholders include funders, research institutions, principal investigators, and even data sources.
- Data collection: It implies consistent and quality-controlled collection of data. Few important aspects include obtaining required authorization, using appropriate methods, and applying attention to details.
- Data storage: It implies protection of data from damage, loss, or theft. Data storage is important to recheck the findings, to prioritize research activities/tasks and to be reanalyzed by others.
- Data sharing: It implies deciding what to share and with whom (general public or other researchers) to share the preliminary data or final results. Data withholding is also an important aspect.

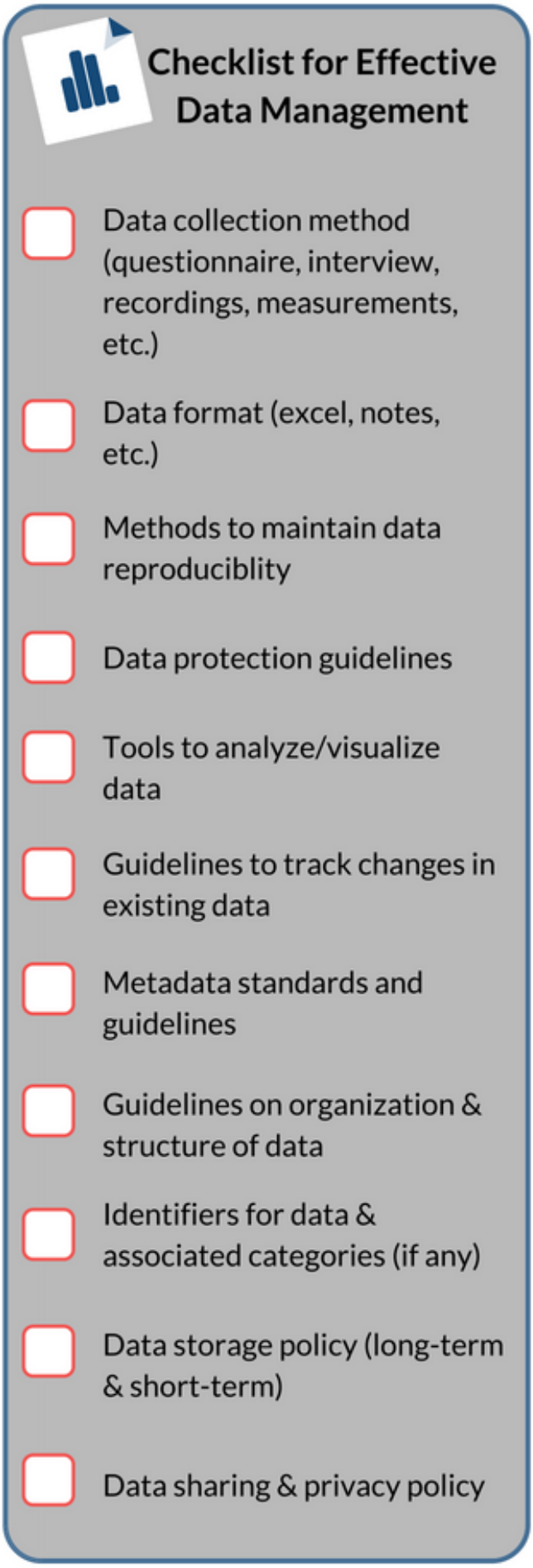
Researchers have the responsibility to maintain the integrity of the research data. The group members involved in the handling of the data should maintain privacy and confidentiality of the data while recording on hard-copy or electronic evidence.

Lapses in the management of research data can give rise to many ethical issues. These issues are more prominent in studies involving human subjects.



Researchers should, therefore, provide data management plan (DMP) to ethics committees for clinical studies/trials for approval.

Moreover, informed consent to obtain data and protecting or anonymising a certain part of data during analysis or sharing should also be proactively implemented. An effective data management plan can help you avoid ethical issues [14]. Refer to this checklist for few important points.



ASSIGNING AUTHORSHIP

Do you know the importance of the names appearing at the top of a research or a review paper? Allocating authorship allows researchers to assign appropriate credit and acknowledge their contribution to the research. However, assigning authorship is not always that simple as it also implies accountability and responsibility for the published work. Authorship issues can sometimes lead to conflicts and give rise to misconducts.

Many journals now, therefore, request researchers to submit contributorship statement mentioning the role of each researcher.

According to ICMJE [15], an author must satisfy these four criteria.

- Made substantial contributions to the design and conception of the study; data collection, analysis, and interpretation.
- Drafted or revised the intellectual content/ output.
- Approved the final version of the manuscript for publication.
- Agreed to be accountable for the research work, ensuring that queries related to accuracy or integrity of the research are resolved.

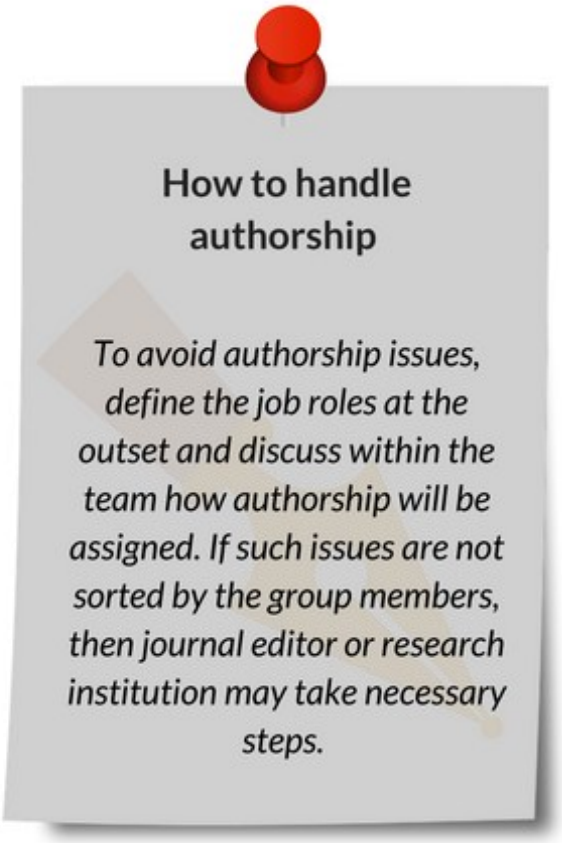
Moreover, the author should be able to identify which co-authors are responsible for which part of the work.

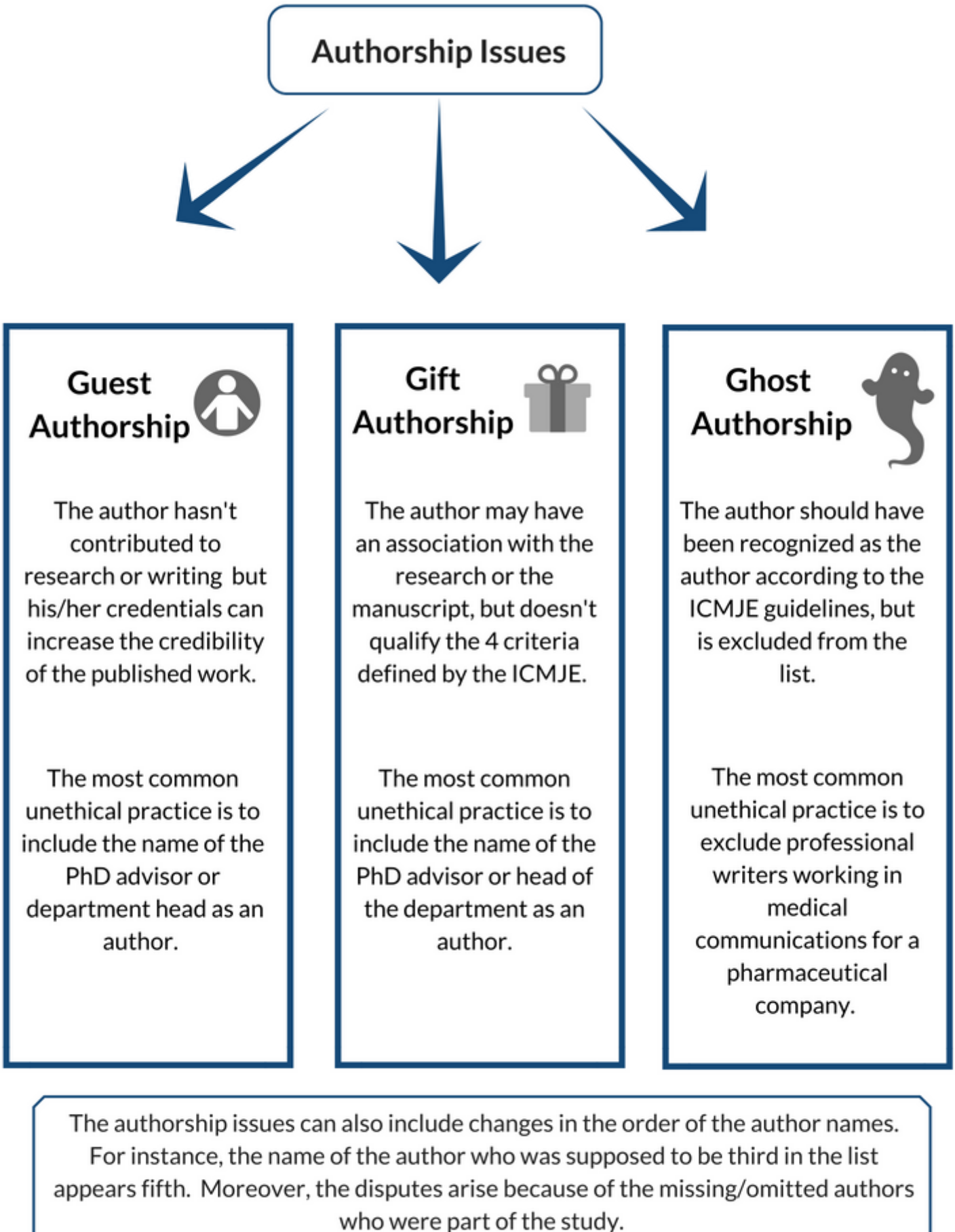
According to ICMJE, in a large multi-author study, the decision on authorship should be taken before submitting a manuscript to the journal. Each author of such studies should qualify those four criteria and individually submit conflicts of disclosure forms to the journal editor. Additionally, some large multi-author groups can choose a group name to assign authorship. In that case, a group name should be used when making a submission to the journal along with a description of who all qualify as authors in that group.

What about individuals who do not qualify all four of the criteria, but have contributed to the study? You should make sure to acknowledge them as contributors. Contributors usually help in the acquisition of funding, supervising research group, providing administrative support, assisting in technical writing, editing, proofreading, etc.

Apart from that, the corresponding author communicates with the journal during manuscript submission, peer review, and publishing. He/she ensures that all the documentation requirements related to ethics committees approvals, authorship, conflict of interest, clinical trial registration etc. are met [15].

Read through the figure below to identify disputes and misconducts in authorship. Researchers, especially those at the early stage of their careers should ensure to follow appropriate author guidelines by the target journal or international organizations such as ICMJE, World Association of Medical Editors (WAME), and the American Medical Writers Association (AMWA). You can also consult your advisors or mentors to solve these issues.




Authorship Issues
Guest Authorship
The author hasn't contributed to research or writing but his/her credentials can increase the credibility of the published work.
The most common unethical practice is to include the name of the PhD advisor or department head as an author.
Gift Authorship
The author may have an association with the research or the manuscript, but doesn't qualify the 4 criteria defined by the ICMJE.
The most common unethical practice is to include the name of the PhD advisor or head of the department as an author.
Ghost Authorship
The author should have been recognized as the author according to the ICMJE guidelines, but is excluded from the list.
The most common unethical practice is to exclude professional writers working in medical communications for a pharmaceutical company.
The authorship issues can also include changes in the order of the author names. For instance, the name of the author who was supposed to be third in the list appears fifth. Moreover, the disputes arise because of the missing/omitted authors who were part of the study.

AVOIDING PLAGIARISM

When drafting the manuscript, authors refer to published/unpublished work to draw upon ideas or to support their statements. However, researchers often end up in plagiarism trap intentionally or accidentally. Plagiarism is defined as an unethical practice of using someone else's work, ideas, data, concept, words, methods, images, etc. without proper acknowledgment and presenting them as their own [16]. It is a serious misconduct and professional infarction. Therefore, it is important to give appropriate credit to the author or the source.

The severity and extent of plagiarism can vary [17] and can fall under the following categories.

- Complete plagiarism/ intellectual theft: Submit work under one's name when somebody else has created it.
- Source-based plagiarism: Reference a source that is incorrect or does not exist i.e. a misleading citation. May also occur when the author cites only the primary source without citing the secondary source from where information was obtained.
- Verbatim plagiarism: Copy word-to-word from original work without quoting & citing it.
- Self plagiarism: Reuse significant portions of own previously published work without attribution.
- Paraphrasing plagiarism: Use someone else's writing with some minor changes in the sentences (using synonyms) and using it as one's own.
- Mosaic/patchwork plagiarism: Interlay someone else's phrases or text within own work.

Plagiarism is a serious offense. It can not only have legal implications but also damage the credibility and reputation of the author. In academic publishing, plagiarism can lead to retraction of the published work and loss of academic positions or jobs. Read through the figure below for effective tips to avoid plagiarism when drafting your manuscript.

Authors can also use plagiarism checkers such as PlagScan, iThenticate, etc. to avoid text plagiarism. However, all plagiarism checkers are not created equal. While few have access to premium databases (e.g., Crossref) for similarity check, others do not

Quoting

- When using word-to-word (verbatim) text from any source, use quotation marks for the extract and cite the source.
- For longer extracts, some style guides recommend using block quotes.

Summarizing

- When summarizing, use your own words to convey the main message/idea of the original work in an abridged form.
- Make sure to cite the original source.

Paraphrasing

- When paraphrasing original work, make sure to use your own words and sentence structures to convey the same meaning.
- Always cite the original source.

Common knowledge

- Universal truths or facts expected to be known to readers need not be cited.
- Cite statistical information or lesser-known facts. When in confusion whether the fact or statement is a common knowledge or not, always cite to remove any doubt!

PUBLISHING RESEARCH ETHICALLY

Researchers primarily use journal articles or books to communicate the results of their research to the scientific community and general public. Therefore, following publishing ethics is equally important for researchers and journals. Journals require authors to disclose whether the same research has been published before or is being considered for publication elsewhere. Duplicate publications and simultaneous submissions account for serious misconduct! Often, in biomedical research, authors present same data with different analyses (of a subgroup). In that case, authors should disclose the original source of the data and previous publications when making a submission. ICMJE define simultaneous submissions and duplicate publications as follows [18]:

Submission.

- Simultaneous Submissions: Submitting same manuscript in same or different language(s) to one or more than one journal at the same time.
- Duplicate publications: Publishing a paper that is significantly similar to the paper published previously.

The Committee on Publication Ethics (COPE) has outlined guidelines for journal editors to identify and avoid such misconducts in submitted manuscripts and published papers [19, 20].

Researchers should consider the following points to avoid unethical publishing practices [21].

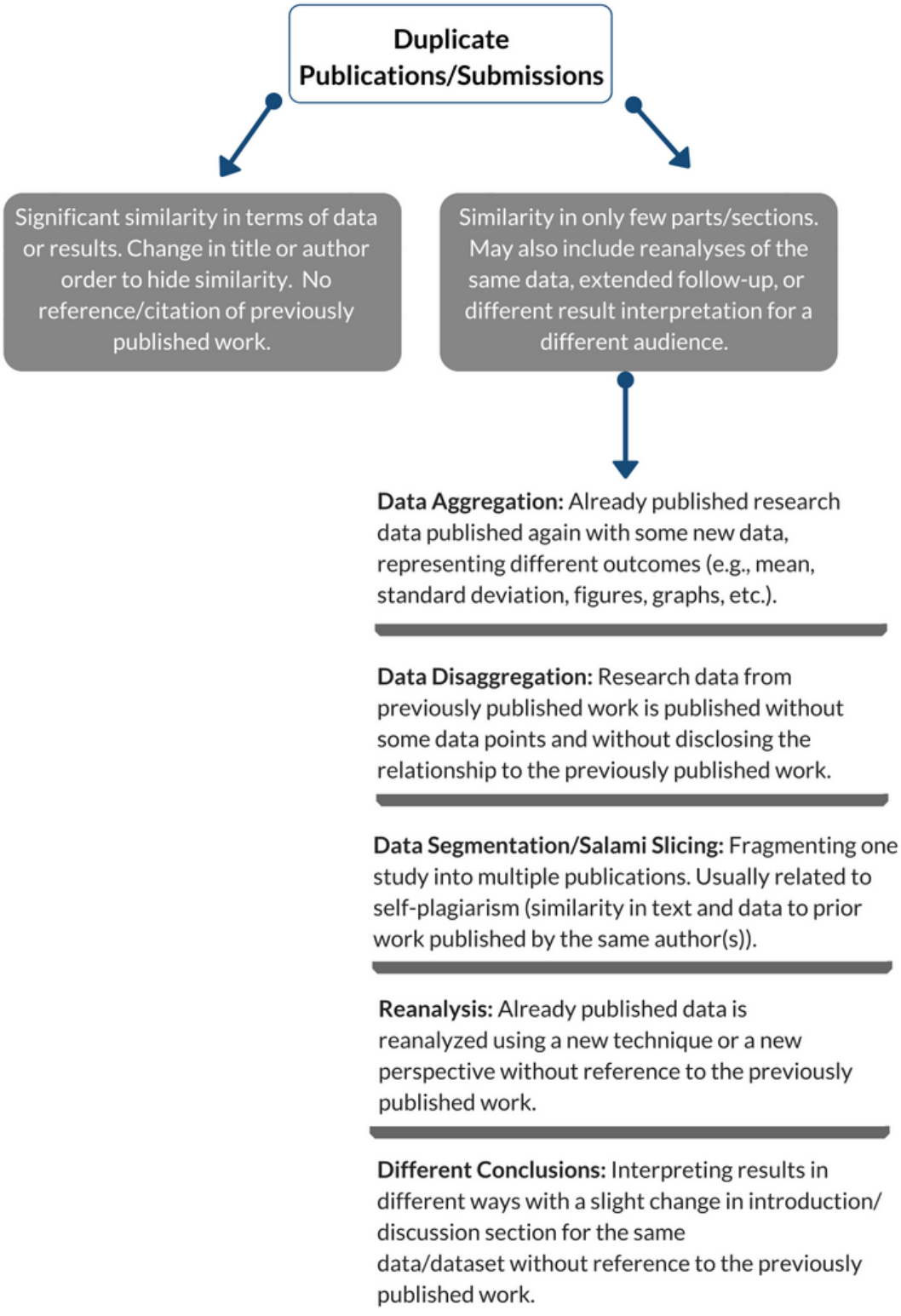
- Do not submit the same paper to different journals.
- Maintain transparency during submission and peer review process on previously published work (disclose publication in conference proceedings, submission to a pre-print repository etc.).
- Check with the publisher about translating and publishing the work again.
- Disclose already published and/or translated versions of the submitted manuscript.
- Avoid dividing your study into multiple publications.

Journals may allow secondary publications in certain cases [18].

- Author(s) have got approval from the editors of both the journals (ensure they have access to the original/primary

published work).

- The editors have agreed on the publication interval between the primary and secondary publication.
- The secondary publication refers (cite) to the data and interpretation of the primary publication.
- The secondary publication informs readers that primary publication has been published previously (whole or in parts) by citing it appropriately.
- The title should indicate that it is a secondary publication.



4. RESEARCH MISCONDUCT

WHAT IS RESEARCH MISCONDUCT?

The ORI defines research misconduct as fabrication, falsification, or plagiarism in designing, conducting, or reviewing research or in reporting the findings of the research [22].

Falsification involves misrepresentation of the research by changing data or results or by tampering with equipment, research methods, or materials.

Fabrication involves reporting false or made-up data, results, or research outputs.

Plagiarism involves presenting others' ideas, works, or words without acknowledging or providing appropriate credit to the original authorship.

What about errors that are unintentional or situations that arise because of different opinions? These do not fall under scientific misconduct or fraud.

Universities and research institutions define policies and guidelines for researchers to maintain scientific integrity while conducting research. These guidelines also provide information on how to report any such cases. Make sure you are aware of your university's policies.

Most cases of scientific misconduct involve image or data manipulation. Researchers are often not aware of the nuances between image modification and manipulation. They use image processing tools without having appropriate training in concepts such as vector graphics, RGB vs. CMYK, continuous-tone images, etc. [23—25].

IMAGE MANIPULATION

- Consider your image as data
- Retain original copy of images
- Make simple adjustments when modifying images
- Crop within acceptable standards/limits
- Collect image data that needs to be compared under same conditions
- Change the size (pixels) of images carefully
- Exercise caution when changing magnification or resolution of images
- Make intensity measurements on raw data, calibrated to an accepted standard

- Clone an object on your image
- Manipulate/modify only specific areas of images to highlight or alter background
- Use filters in the software especially on biological images
- Crop such that the inference of the remaining image changes
- Alter brightness or contrast to fade an object or clear the background
- Make colour changes that alter the inference of the imahe
- Resize image that alters aspect ration, resulting in change in boundaries, shape, etc.

ORI has developed **Droplet,** a small desktop application in Adobe Photoshop® that automatically processes image files to detect image manipulations. Apart from that **Adobe Bridge** and **ImageJ** are also helpful forensic tools.

RESEARCH REPRODUCIBILITY

Reproducibility in research is important to validate findings. What is reproducibility? Reproducibility is defined as when a researcher is able to duplicate the same phenomenon even when experimental conditions are varied. Whereas, replicability is defined as when a researcher is able to obtain same results when the experiment is conducted under same experimental conditions [26].

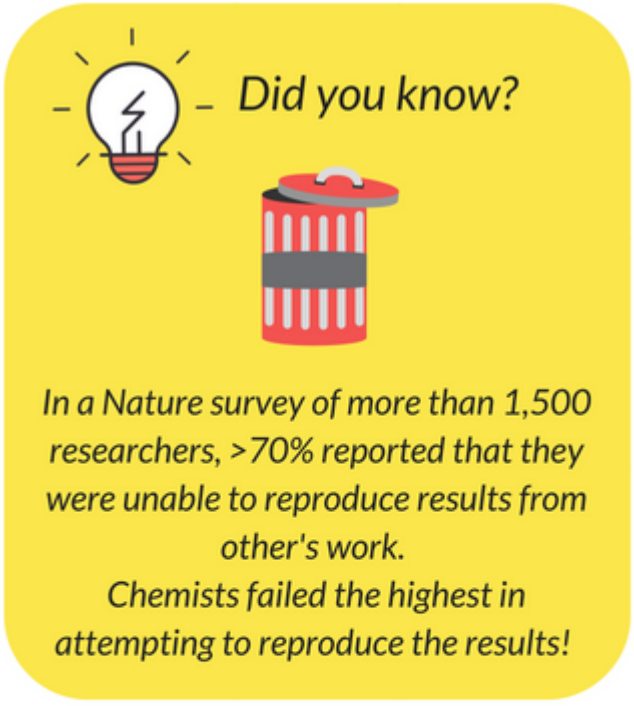
Although reproducibility is promoted in science, researchers are not keen to replicate or read published results. Moreover, published work is expected to be reproducible but its rarely tested on those grounds later.

It is the responsibility of the researchers to promote reproducibility. So, how can you ensure that your work is reproducible?

- Write detailed experimental protocols that are easy to understand/implement.
- Share your research outputs in an open access repository to make them accessible.
- Perform experiments (with variations) in duplicates/triplicates to increase the robustness of your findings.
- Refrain from data fabrication or manipulation.

It is important to note that reproducible research is not always correct [27]. There are many instances as follows.

- False positives in published research.
- Bad quality of data and data analysis.
- Poor study design.
- Missed confounding variables.
- Omitted data points.



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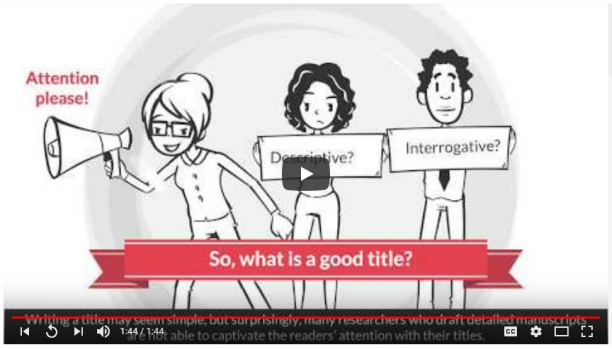

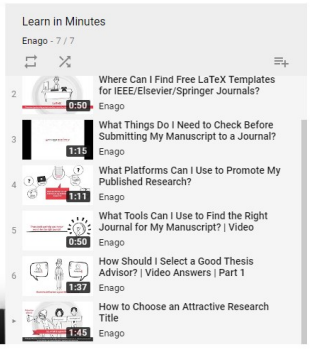

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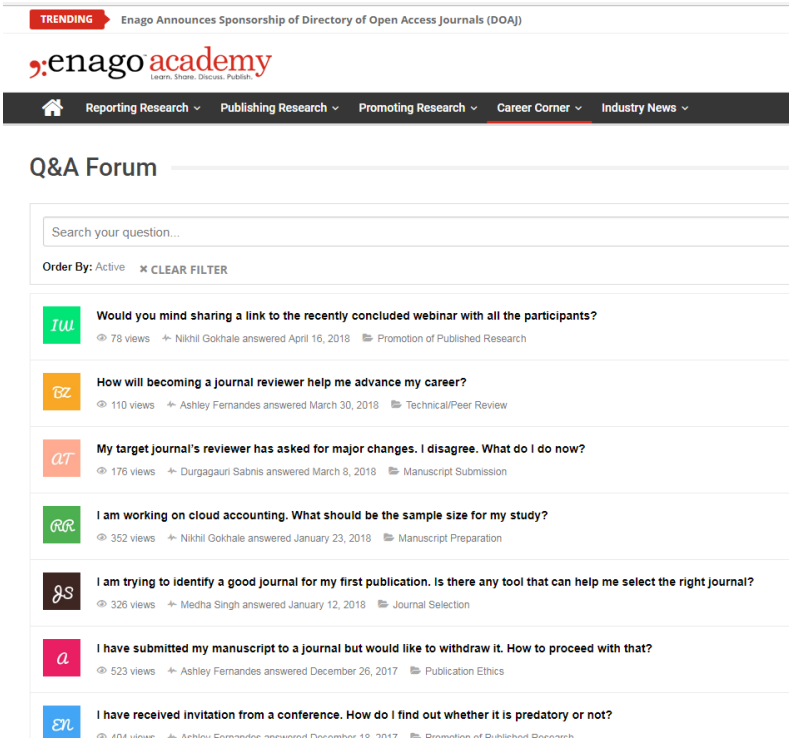

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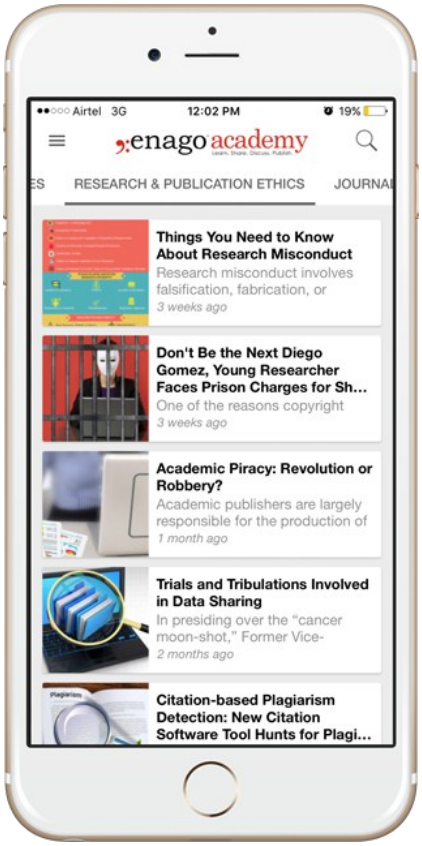

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