WRITING A RESEARCH MANUSCRIPT

GOALS OF PUBLISHING A RESEARCH MANUSCRIPT

Researchers communicate findings to the scientific community through published articles. Thus, by publishing your research, you contribute to your field of study. Further, strong publication records are essential in today's research climate, which emphasizes the idea of publish or perish. Additionally, publishing clear, well-written, rigorous studies can establish you as a successful scientist who can execute projects and get meaningful results. Finally, frequently publishing your research establishes your research niche within the larger research community, and people will think of you as a topic expert.

Publishing a research article entails more than conducting research and putting together your findings. Yes, your findings must be impactful, and your research must be rigorous, but this alone is not sufficient to publish your work. You must thoughtfully compile your research findings into a clear narrative that engages readers and clearly communicates your findings and the importance of your work. Further, the methods used must be clearly explained and justified, and data must be presented clearly and concisely. Importantly, all essential information must be included in the manuscript before it will be accepted for publication.

In this document, we provide information on the main components of the research manuscript, following the IMRAD (Introduction, Methods, Results, and Discussion) format. We also provide a brief overview of the manuscript submission process and the ethics of publishing a research manuscript, and we explain how authorship is determined. Finally, we provide resources for further learning.

Please remember that each journal website has Instructions for Authors, which are available on journal websites, and these author guidelines will always supersede the recommendations included in this document. Please select your target journal and refer to author guidelines before you write your manuscript. For help writing and editing research manuscripts, please contact the Science Communication Group (SciCom) at the University of Arkansas for Medical Sciences.

STRUCTURE AND COMPONENTS OF THE RESEARCH MANUSCRIPT

The standard research manuscript follows the IMRAD (Introduction, Methods, Results, and Discussion) format. This format allows for the clear communication of research and provides a standardized format for reporting findings. By following this format, which is often required by journal guidelines, you can easily develop a clear research narrative. Follow the IMRAD format unless your target journal states otherwise.

In the following subsections, we summarize key aspects of the manuscript, including the Title; Abstract/Keywords; Introduction; Methods; Results; Figures, Figure Legends, Tables, and Schematics; Discussion; References; Acknowledgments; Supplemental Materials; and Cover Letter.

Title

The title must convey the main conclusion of your manuscript (i.e., the take-home message). Your take-home message must be justifiable based on your data; do not oversell your findings. Keep the title short and always check journal instructions for character limits (often 100–150 characters including spaces, but this varies by journal). Avoid abbreviations and specialized terms in the title; instead, use keywords that will attract readers from your target audience.

Journals may also request a short title, sometimes called a running head (often 40 characters including spaces). Although this title is brief, it must emphasize the main point of your manuscript. When drafting your title, write multiple versions of the title and short title and ask colleagues in and outside of your field which title best describes your research and piques their interest.

Abstract/Keywords

The abstract provides readers with a full summary of your project. Although the abstract summarizes all aspects of your manuscript, it must be concise to meet the word limit set by the journal (often 250 words). Your abstract should be understandable to a broad audience because you want to attract many readers. Start with broad background information but quickly guide the reader to the gap in knowledge that your study filled. Then, briefly state the methods used and your main findings. Finally, summarize the significance and impact of your work and provide a broad perspective on how your main finding contributes to your research field. For detailed guidance on writing abstracts, please refer to "Writing a Scientific Abstract" (SciCom Resources).

Keywords, which are often included at the end of the abstract, are important for indexing your manuscript and for helping search engines and databases (e.g., PubMed) cite your work. Thus, selecting keywords for your manuscript should not be overlooked. Your keywords should summarize key concepts—both broad and specific—and methods. To identify keywords, use Medical Subject Headings (MeSH). MeSH is the National Library of Medicine's list of keywords for cataloging medical publications. Journals often have limits on the number of keywords permitted; thus, check author guidelines for your target journal.

Introduction

The goal of the Introduction is to orient readers to the following: your broad research interest, the specific gap in knowledge that your study filled, and the significance of your work. Often, Introductions are written in active voice, with "we" used to refer to the authors of the manuscript. Present tense is used to describe facts, whereas past tense may be used to describe prior research findings. In general, the Introduction should be concise, about 3 to 4 paragraphs max, although the length may vary depending on author guidelines and the type of article that you plan to submit.

First, provide essential background information. For example, describe important scientific concepts, key genes or proteins, or disease states. This should not be an elaborate literature review; instead, build a narrative that introduces key concepts and background information as it pertains to your study. Think of this as establishing the scientific context of your research (i.e., what is understood in your field).

You must also state the gap in knowledge that your research fills. Likely, you will have 2 knowledge gaps: one broad and one specific. A gap in knowledge states what is unknown in your research field. For instance, if you study Alzheimer's disease, the broad gap in knowledge that your work addresses may be as follows: "Although we know that people with Alzheimer's disease present with protein plaques in the brain, we do not understand how these protein plaques form." You will notice that this gap in knowledge cannot be resolved by one study or even one research team. In contrast, your specific gap in knowledge will directly answer a specific question: Do post-translational modifications of Tau protein contribute to Tau aggregation and subsequent plaque formation? This question is much more specific and can be resolved through your immediate studies.

To make your broad and specific gaps in knowledge clear, follow the organization depicted in **Figure 1**. First introduce broad background information and state the importance of your work. Next, provide the broad gap in knowledge. Then, provide specific background information needed to understand your project. Finally, state the specific gap in knowledge that you answer through your research. This is a clear narrative structure that moves from general information to specific information and is easy for readers to follow.

After defining your specific gap in knowledge, state the specific hypothesis that you tested or, if your research was not hypothesis-driven, state the goal of your research study. Then, briefly, in 1–2 sentences, explain how you tested this hypothesis or accomplished this goal.

These sentences should make clear the type of methods used. Finally, in 1–2 sentences, state the main conclusion (i.e., take-home message) of your study. Doing so provides a clear conclusion to the Introduction and allows readers to understand what is to come.

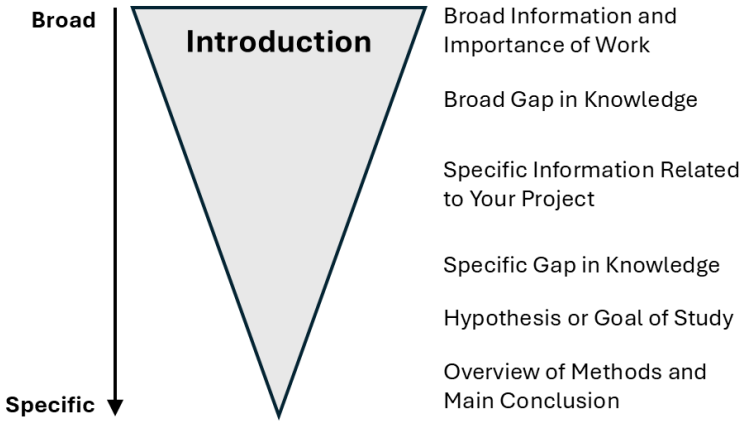

Figure 1. Organization and narrative of the Introduction.

Methods

The Methods section, which is most often written in past tense and passive voice, should describe the methods and analyses used to address the specific gap in knowledge that you defined in the Introduction. This section is essential because peer reviewers will consider the rigor of your methods when reviewing your manuscript for publication. Thus, the design, analysis, and ethical considerations of your studies must be clear.

Break your Methods section into subsections. Each subsection should describe a specific method, and every method described must have a corresponding result that later will be discussed. Subsections should follow a logical flow and should not necessarily be reported in the order in which experiments were performed. Often, it is most logical to put the methods in the order in which they are discussed in Results. Statistical analyses should always be described and often appear as the final subsection in Methods.

Each Methods subsection should contain sufficient information that researchers could replicate your experiments. This means that materials used should be clearly defined. For example, you must provide information on solution and antibody concentrations (not just volumes) and PCR primer sequences. For each reagent, the source of the reagent must be disclosed. Equipment information, including model number, and software information, including version, is required. Manufacturer's name and location must be disclosed for reagents, equipment, and software.

Based on the type of study performed, you may need to include specific information or statements. For example, human studies will require you include a statement about Institutional Review Board approval, whereas animal studies will require a statement about approval from an Institutional Animal Care and Use Committee. It is best to consult journal guidelines, International Committee of Medical Journal Editors recommendations, and the Enhancing the Quality and Transparency of Health Research Network guidelines to ensure you report all required information. Additional information on reporting guidelines per study type can be found in "Types of Articles in Biomedical Research and Study Guidelines" (SciCom Resources).

Results

Here, you describe what you did and what you found. This section should provide evidence for your take-home message while building a narrative for readers to follow. The goal is to communicate your most important results and show how these findings lead to your main conclusion, which you will elaborate on in the Discussion.

The Results section should be divided into subsections. Subsections are often determined based on how experiments are grouped and what conclusions were drawn from said experiments. Each subsection contains a title and describes a set of experiments (often 1–3 figures). The subsection title should state the main conclusion drawn from figures associated

with that subsection. Thus, the subsection title summarizes the individual findings that build toward your main conclusion. Ideally, your subsection title should be written in active voice and contain strong verbs.

The main text of each subsection often follows a set format (**Figure 2**): (**1**) After the title, your opening sentences should state the question, hypothesis, purpose, or goal of the associated experiments. You can begin with statements such as "To investigate whether" and "To determine the extent." (**2**) Then, briefly remind readers of the methods used for this set of experiments. Depending on journal style and whether Methods are presented before Results or at the end of the manuscript, you may include a broad overview of the experimental design, an explanation of specific methods or controls, and a rationale for the experimental design. This ensures reader comprehension. Still, only provide the information readers need to follow the narrative flow and leave specific details about methods in the Methods section. Frequently, Steps 1 and 2 are accomplished in a single sentence: "To determine X, we performed Y assay." (**3**) Then, state your results. Tell readers the results for each experiment and reference figure panels or tables in text. You can begin sentences with phrases such as "We found," "We observed," or "The results showed that." (**4**) Finally, state the simple conclusion that can be drawn from the data. Often, this will be stated as "These results suggest that…." Although you want to state the simple conclusion, you do not want to elaborate on this conclusion. Importantly, the simple conclusion of one subsection should lead the reader directly into the next subsection and the next question that you ask.

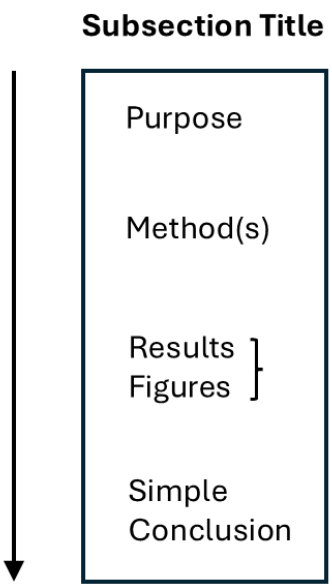

Figure 2. General organization of a subsection in Results.

The Results section relies heavily on data presentation. In the following section, we describe best practices for figures, figure legends, tables, and schematics. All figures and tables must be called out in the text, and the call-out should be placed in bold text in parentheses at the end of the sentence before the period. Figures and tables should be referenced in chronological order within this text. Check journal requirements for information on the number of figures that can be included in the main text. Additional figures and tables can often be provided in supplemental materials.

Figures, Figure Legends, Tables, and Schematics

The data you present and how you choose to present the data are critical. Data can be presented as multi-panel figures or in tables. Typically, figures are used when you want to present images or reveal patterns or trends; in contrast, tables are used when you need to present exact numbers or detailed information.

Figures. Use figures to show patterns or trends in your data or to show representative images. Most figures contain multiple panels, and each panel contributes to the main conclusion of that figure. Although you can have multiple panels, too many panels can overwhelm the reader. Therefore, be strategic with the data you present, and only show the data necessary to make your point.

Present your data in a way that emphasizes the result you want readers to understand. For instance, if you want to compare discrete categories, a bar graph can make the differences clear; in contrast, if you want to show a trend over time, a line graph would be more effective than a bar graph at showing the change over time. Selecting the correct data presentation is essential for making your findings clear.

All figures must be referenced in the text, and figures and figure panels should be presented in chronological order in the text. You will likely need to reorganize your panels as you write your Results sections; you may even need to reorganize the order of full figures. Remain flexible and remember data do not need to be presented in the order collected.

Figures must be understandable without reading the text. Thus, all abbreviations, colors, and symbols must be defined either on the figure or in the figure legend, and abbreviations, colors, and symbols should be consistent across figures. Limit use of color in figures and be sure color is used for emphasis. When considering your figure color palette, consider color palettes that are accessible to people who are color blind. Be sure all images in a figure are the same magnification unless you have good reason to do otherwise. Scale bars should also be included on all images. For graphs, consider your axes carefully to ensure you are accurately representing your data, and when possible, it is best to show all data points rather than hide them with the mean.

Figure Legends. Figure legends help readers understand the data you present. Figure legends begin with an identifier (e.g., Figure 1, Figure 2) and a title that summarizes the figure's main finding. After the title, provide a description of each panel within the figure. These descriptions should help orient readers to the data but should not state results or interpretations of the data. At the end of the figure legend, you must define symbols, especially when symbols represent *P*-values.

Tables. Use tables to provide readers with exact values and information. Information provided in tables should not be repeated in text unless the information is critical to the narrative or take-home message of your study. Like figures, all tables must be called out in text in chronological order. The table identifier (e.g., Table 1, Table 2) and the table title go above the table. The table title should summarize the information in the table. For instance, a table title may start with "Summary of" or "Characteristics of" and offer a concise descriptor of the table content. Each row and column of your table should be labeled with a clear header. All abbreviations and symbols must be defined at the bottom of the table. Footnotes can also be included at the bottom of the table. Tables should be editable and generated in a word processing program, such as Microsoft Word; do not draw tables with graphics software.

Schematics. A schematic diagram helps readers understand key concepts or methods. Depending on the number of figures permitted by your target journal, you may include a schematic diagram to help readers understand, for example, important signaling pathways, your main hypothesis or goal, or your study design. Schematics should facilitate understanding and should not be overly complex. Design your schematic from left to right, and, as with figures, use color with purpose (i.e., emphasize only the key concepts). Ensure text within the schematic is large enough to read and all abbreviations or symbols are defined. A schematic will count as a figure and will require a figure legend.

Discussion

Here you discuss the implications and significance of your work. This is one of the most challenging sections to write because the Discussion requires you to put your results into context with prior research in your field, discuss the immediate and long-term impact of your work, and describe limitations of your and other relevant studies. Thus, your Discussion will likely be one of the longest sections in your manuscript.

Figure 3 depicts the general organization and narrative of the Discussion. To begin, state the major findings of your study. Do not restate all your results but do summarize the major findings and the main take-home message. Emphasize that your findings fill the gap in knowledge you established in the Introduction.

In the next few paragraphs, explain how your findings fit into your field. Readers must understand the implications of your findings and why your findings are important. If your

research was hypothesis-driven, discuss whether your findings support or reject your original hypothesis. Mention whether your findings are consistent with similar studies in your field, and if they are not, discuss why you observed differences. Consider whether there are any alternative interpretations or explanations for your findings. Mention any limitations of your study and how these limitations may have affected the results.

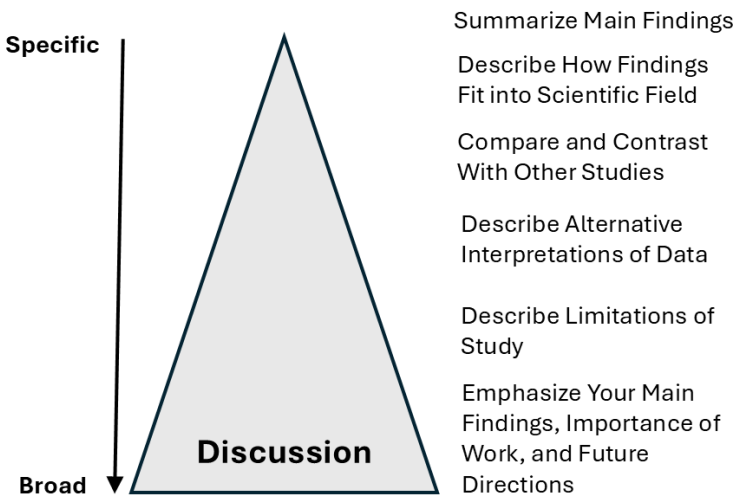

Figure 3. Organization and narrative of Discussion.

End your Discussion on a strong point. In your final paragraph, re-emphasize that despite the limitations, your results fill an important gap in knowledge. Here you can re-emphasize clinical relevance, your take-home message, and the broad impact of your work. You may also touch on future directions that arise from your study.

Common pitfalls in the Discussion include the following: (1) Failing to discuss papers that were published during the time in which you conducted the research; do not limit yourself to what was known at the time you began the research project. Include all relevant literature. (2) Overinterpreting results, overselling the work's importance, or drawing conclusions not supported by the data. (3) Writing a literature review of your field or discussing studies that do not directly pertain to your work. Maintain a strong narrative flow tied directly to your findings. (4) Finally, including new results in the Discussion. All results must be presented in Results, and you should only discuss your most interesting and important findings in the Discussion.

References

Throughout your manuscript, include references to support your claims and show that you understand how your study fits into the current literature landscape. This is especially true in the Introduction and Discussion where you want to show how your gap in knowledge and findings fit into the field. This is also true for Methods where you want to provide evidence to justify use of a particular method. Providing references also gives credit to researchers who performed studies that established the foundation for your work and prevents you from plagiarizing people's ideas or phrasing. Finally, references provide the reader with additional resources.

You should consider the following when deciding on references: (1) Do not only cite your own studies. Although you may need to cite your own work to establish the foundation of your project, you must also reference the work of others. (2) Do not limit your references to studies that were available at the time at which you started the project. You must consider all literature available at the time of writing your manuscript. If new literature relevant to your study is published as you write your manuscript, you must discuss this in your manuscript. (3) Journals set limits for number of references permitted. Please check author guidelines to determine the number of references allowed. When possible, cite the original research finding rather than a review article, but citing reviews may be necessary if the journal has a tight limit on number of references. (4) Finally, before submitting your manuscript, you must check all references for accuracy and ensure you followed journal guidelines for reference format.

Acknowledgments

Include the following in Acknowledgments: (1) Funding sources that supported the study, (2)

people who carried out the work and what their role in the study was, (3) people involved in research collection or drafting of the manuscript who did not meet criteria for authorship, (4) conflicts of interest, and (5) any previous presentations of results/content (e.g., a published conference abstract or publication as preprint [e.g., bioRxiv]). Journals may also require specific statements in the acknowledgements, such as a data sharing statement or a statement indicating whether you used an editing service, such as SciCom, when preparing the manuscript. Check author guidelines to ensure you covered all required information.

Supplemental Materials

Supplemental materials vary. For example, in short reports, the number of in-text figures is extremely limited, and thus a large amount of data is presented in the supplement. For longer publications, in which most data can be presented in text, the supplemental material may contain large datasets, specific code used for data analysis, detailed methods, or videos and other multimedia files. The supplement should not be an afterthought. You must be thoughtful about what you include in supplement and ensure the data support the main narrative. Supplemental material must be submitted with main manuscript text. Often, journals do not copyedit the supplemental materials. Thus, it is your responsibility to ensure files are polished and information is accurate.

Cover Letter

The cover letter is your chance to sell your science. The cover letter, which should be 1 page, is written to the editor, and this is your opportunity to explain why your work is an excellent fit for the journal. In the cover letter, emphasize what is new and novel about your findings, why your findings are important, and why readers of the journal would be interested in your work. Remember, the cover letter should be persuasive. Some journals require specific information be stated in the cover letter, such as any conflicts of interest with reviewers or whether the manuscript is under consideration at other journals. Always check journal guidelines.

AUTHORSHIP, ETHICS, AND THE MANUSCRIPT SUBMISSION PROCESS

Authorship

The order of authorship matters. First author indicates that you led the project and made the most significant contributions, both intellectually and in terms of conducting experiments and data analysis. Before starting a project, determine who will be first author on the project. The last author is typically the senior author who oversaw and funded the project. Middle authors are often ordered based on the degree to which they contributed to the project, either by conducting experiments or data analysis or adding intellectual insight or ideas.

Four criteria must be met to qualify for authorship: (1) contributed intellectually or acquired and analyzed data, (2) helped write and edit manuscript, (3) took responsibility for the published work, and (4) approved final manuscript. If these criteria are met, the person qualifies for authorship. If not, the person's contribution should instead be mentioned in Acknowledgments. For additional guidance on determining authorship, please refer to the ICMJE guidelines on authorship.

Ethics

Ethical publication practices are necessary. You must accurately represent your results, and data manipulation is not permitted. Journals will screen your data for manipulation, and often you are required to submit raw data along with your final figures. Thus, keep data organized as you generate figures. You must present your own work and your own ideas. Further, only people who meet the criteria for authorship should be included as authors. Be transparent about conflicts of interest, and check journal guidelines for use of artificial intelligence (AI) in writing your manuscript. If you used AI or large language models, you must disclose this use. Finally,

when carrying out human or animal studies, you must have appropriate approvals in place, and these approvals must be clearly stated in the manuscript.

Submission Process

Most journals follow a similar workflow for reviewing your manuscript. First, compile a polished, complete manuscript that is formatted to the guidelines of your target journal. Then, submit to the journal, typically done through the journal's online submission portal. From here, your manuscript will undergo initial editorial review. If your manuscript fails to meet the journal's basic criteria for publication, the editor will reject your manuscript. If your manuscript is of interest to the editor and the journal's readership, it will be sent out for peer review. Typically for peer review, 2 or 3 experts in the field will evaluate the rigor of your work and the validity of the conclusions. They will also assess whether the work is important to the field. After peer review is complete, the editor will decide based on the peer reviewer feedback whether to accept your manuscript for publication. Often, manuscripts are either accepted as is, accepted with minor revisions, accepted with major revision, or rejected. Regardless of the decision, you must always respond to the editor respectfully. If your manuscript was accepted with revisions, explain the changes made or explain why certain changes are not feasible. Once accepted, the manuscript will go through its final production (e.g., copyediting and proofs).

In recent years, the number of predatory journals targeting researchers has increased. These journals require payment for fast publication but provide little in return, such as peer review or editorial assistance. Publishing in predatory journals can hurt your scientific reputation, and thus, you must vet the journals in which you plan to publish your work. If you are not familiar with a particular journal, take steps to ensure that it is reputable before submitting your manuscript.

Resources: UAMS Library and DOAJ Principles of Transparency and Best Practice in Scholarly Publishing.

CONCLUSIONS

Crafting a strong research manuscript requires careful planning and attention to detail. Start early, leave time to edit, and gather feedback from colleagues. If you do so, you will soon see your data and ideas transform into a publication-ready paper. For tips on how to get started writing a manuscript, see "Writing Your Research Manuscript: Tips & Tricks for Getting Started" (SciCom Resources).

ADDITIONAL RESOURCES

Iverson C. Manuscript Preparation for Submission and Publication. In: *AMA Manual of Style: A Guide for Authors and Editors.* 11th ed. Oxford University Press; 2020:13–58.

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