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Structure and organization

It is structure that we look for whenever we try to understand anything.

Linus Pauling

Communication is all about transmitting your message to your audience, so it is crucial to keep both your message and your audience in mind at all times. Writing and rewriting can help you define and refine your message, and the way you structure and organize your information has an enormous impact on how successful you are at transmitting your message to your audience.

Some of the most important decisions a writer faces involve what to include and what to leave out. These decisions should be guided by the intended audience—different groups of readers will be interested in different details. For instance, when writing for a general medical audience you need to include more background information than you do when writing for an audience composed of members of your specialty or subspecialty, for whom such details would be superfluous. On the other hand, members of your subspecialty will appreciate detailed information about methods and procedures that might overwhelm and distract readers from other backgrounds. The journal's aims and scope will give you a picture of its readership and help you to decide what to include in your manuscript and how to focus your message.

When you have decided on the focus and depth of the information to include in your manuscript, you must decide how to organize and structure the information you want to present. In scientific journal articles, the journal specifies the format, nearly always a variant of the IMRaD (Introduction, Materials & Methods, Results, and Discussion) design. In grant applications, the agency managing the funds specifies the format, but the basic structure tends to be similar across agencies. In each case, the text is conveniently divided up into major sections where readers can expect to find a predetermined type of information. In each of these sections, you need to provide all the necessary information but only the appropriate information. Moreover, you need to structure the information you provide in each section to make it as easy as possible for readers to grasp your message, creating subsections within sections, marking them clearly with headers when convenient, and organizing paragraphs and sentences in a logical order. Your goal should always be to arrange the information in the document to make it as easy as possible for readers to follow the thread of your arguments and comprehend your message.

IMRaD structure for research papers

Most papers reporting original research follow the IMRaD structure: Introduction, Methods, Results, and Discussion. Each section contributes to the overall story by answering one or more questions:

- *Introduction*—What problem, question, or hypothesis did you study? Why should it interest readers?
- *Methods*—What did you do to answer the question?
- *Results*—What did you find?
- *Discussion*—What is the meaning and value of your results?

This format works well for studies in which the experiments are planned in advance or performed in a pre-defined order. Examples of this type of studies include randomized controlled trials, intervention trials, and observational studies. Nevertheless, authors reporting other types of studies are often forced to adapt their texts to this format.

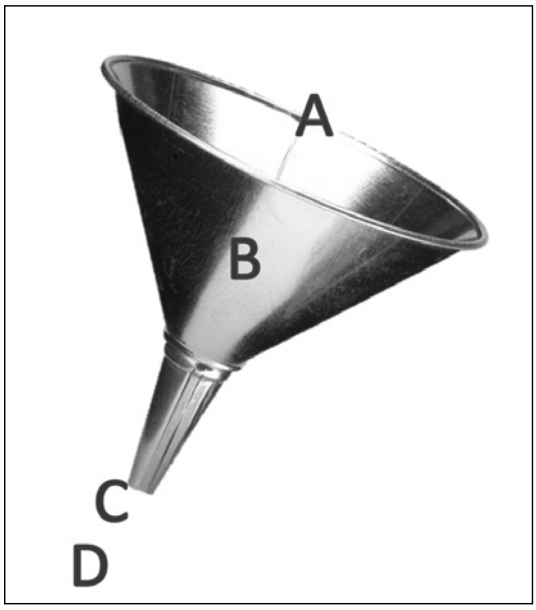

Figure 1. Organization of the introduction. A) The Known. B) The Unknown. C) The Question. D) Experimental Approach.

The introduction

The introduction has two goals: first to spark the readers' interest in your paper and second to provide a context to prepare them to understand it.

1) STRUCTURE: The introduction should be organized like a funnel (Fig. 1). Begin by providing general background information on the topic of the paper (A - The Known). Continue by focusing on what remains unknown (B - The Unknown). Show the reader that there are important missing pieces of the puzzle that need to be filled in. Narrow your discourse to the question (C – The Question), which is the topic of your paper. Finally, it is sometimes useful to include a brief description of your experimental approach (D - Experimental Approach) to smoothly guide the reader to the next section of your paper.

2) TENSE: Most introductions use a variety of tenses. The present tense is used for established facts. *Prokaryotes store their DNA only in the cytoplasm. Untreated, diabetes can cause many complications.* The present tense is also used when a specific paper or result is the subject of the sentence. *Gallant et al.*[2] *showed that the drug is safe at low doses. Peters et al.'s study details the pharmacokinetics of...* The present or present perfect tense is used to talk about past research results that

are still valid. *Several studies have shown that drug X is effective against Gram-negative and Gram-positive bacteria.*[2-5] *Recent genome-wide association studies investigating bipolar disorder have detected a number of susceptibility genes.*[4-8] The past tense is used to refer specifically to methods used in previous studies. *Kuralt et al.*[3] *used reverse transcription PCR to detect swine flu virus in cats.* The past tense should also be used for statements about past conclusions that are no longer true. *It was thought that most heat was lost through the head.* The hypothesis is introduced with the past tense but can be stated in either the present or conditional tense. *We hypothesized that CRH plays a crucial role in... We sought to determine whether higher doses would be more effective...*

3) SIGNALING TOPICS: Useful language for signaling topics in the introduction include:
   - *The effect of A on B is well known.*
   - *X is associated with Y and Z, but the relationship between Y and Z is poorly understood.*
   - *Recent developments in X have underlined the need for...*
   - *Little is known about the mechanisms underlying...*
   - *To date there has been little agreement on what...*
   - *The data from experimental models are inconclusive...*
   - *We aimed to determine whether...*
   - *We sought to elucidate...*
   - *We hypothesized that...*
   - *We tested the hypothesis that...*
   - *To answer this question,...*

The methods

1) STRUCTURE: The methods section is also called the "materials and methods", "patients and methods", "study design", or "experimental" section. The goals of this section are to enable readers to *a)* understand how the experiments were performed, *b)* understand how the results and conclusions were obtained, *c)* reproduce the study, and *d)* determine whether the results and conclusions are valid based on the strength of the methods and study design. To accomplish these goals, the methods section should answer the questions *Who? What? When? Where?* and *How?* in your study (Table 1).

2) TENSE: The methods section is written mostly in the past tense; the present tense is only used to introduce figures and tables. It is crucial to organize the material to help readers understand what you did. You will usually have to divide the methods into subsections and mark them clearly with subheadings. It is also crucial to define all the variables, experimental studies, and groups clearly in this stage of the article. The methods section is the only section in where the passive voice still predominates, although you should not be afraid to use the active voice when it comes naturally. Remember, you should include only the details that are truly relevant.

3) SIGNALING TOPICS: Useful language for signaling topics in the methods section include:
   - *To establish whether...,*
   - *Blood samples were obtained from the antecubital vein...*
   - *The institutional review boards at each participating center approved the study protocol and waived the need for consent.*
   - *We prepared X according to the procedure used by Allan et al. (1987)...*
   - *...as described previously,*[12] *we...*
   - *...described elsewhere.*[15]
   - *Eligible women who matched the selection criteria were identified by...*
   - *Patients with a history of heart disease were excluded...*
   - *The design of the questionnaires was based on...*
   - *We recorded the following variables for each patient admitted to the ICU:...*

Table 1. Some questions that often need to be answered in the Methods section.

Who Who were the patients/subjects? Who collected and reviewed the data? Who did the statistical analyses? Who reviewed the protocol for ethics approval?... As elsewhere in your manuscript, provide only the absolutely necessary details. For example, it may be important that the data were collected by an individual that was blinded to the patients' group assignments, but not that this person trained at a prestigious institution. Likewise, it might be useful to mention that images were interpreted by a neuroradiologist with 10 years' experience in advanced MRI techniques (because this may affect the results), but not that the statistical analyses were done by a statistician.
What What was the experimental design? What specific methods were used? What type of study was it? What were the inclusion and exclusion criteria? What interventions were carried out? What were the endpoints/dependent variables of the study? What was the cutoff for statistical significance? What control studies were performed? What statistical tests were used and what programs did you use to carry them out?...
When When were specimens collected? When were the analyses performed? When was the study initiated? When was the study terminated?...
Where Where were the specimens analyzed? Where were the study participants enrolled? Where was the study performed?
How How were samples collected, processed, and stored? How is the data reported? How were the patients/subjects recruited and/or selected? How was the sample size determined? How were study participants assigned to groups? How were response and endpoints measured?...

- *The primary outcome variables were...*
- *In patients readmitted to the emergency department, only the first admission was included in the analysis...*
- *Publications were only included in the analysis if...*

The results

1) STRUCTURE: Try to summarize the data (facts and figures) obtained in your study in tables and figures. These key elements will support your results, in other words, the statements you make in the text to explain what the data show. However, you should not report every finding in the results section. Rather you should limit your reporting to those that answer the question posed in the Introduction, although it is alright to include unexpected findings that are truly interesting. You need to organize the information you present in the results section very carefully. As always, you should aim for a logical order that helps readers make sense of your findings and grasp your message. To a certain degree, the order in which you present your results depends on what you want to emphasize. You can follow the order you used in the Methods or you can report them in chronological order; alternatively you can group them by topic or by experiment. You might find it best to go from general to specific, a common form in clinical studies that include multiple groups receiving different treatments, or from most to least important.

Avoid mentioning details of the experiments that yielded the results; this information belongs in the methods. Likewise, avoid commenting on the results or stating conclusions; this information belongs in the discussion. You rarely need to cite references in the results section, as you are reporting your own work in this specific study.

Table 2. Reporting guidelines.

- Consolidated Standards of Reporting Trials (CONSORT: www.consort-statement.org/)
- Strengthening the Reporting of Observational Studies in Epidemiology (STROBE; www.strobe-statement.org/)
- Metaanalyses of Observational Studies in Epidemiology (MOOSE; JAMA 2000;283:2008–12)
- Enhancing the Quality and Transparency of Health Research (EQUATOR; www.equator-network.org)
- Preferred Reporting Items for Systematic Reviews and Metaanalyses (PRISMA; www.prisma-statement.org/)

Specific guidelines for reporting results in several kinds of studies are available online (Table 2). Following these standards for reporting can help you develop an accurate and complete results section.

2) TENSE: The past tense predominates in the results section. The present tense is used to refer to tables and figures. *The baseline hemodynamic variables are reported in Table 1. Figure 2 shows the time profile of geometric mean values for total lymphocytes from all dosage groups.*

3) SIGNALING TOPICS: Useful language for signaling topics in the results section include:
   - *Table 1 presents the results obtained from the preliminary analysis of X...*
   - *There was a significant positive correlation between...*
   - *The pigs' blood pressure increased with each challenge (Table 1).*
   - *There were no significant differences between...*
   - *The response rate was 20% at six months and 54% at twelve months.*
   - *We found (no)... We observed (no)...*
   - *Table 2 reports/shows...*
   - *Figure 1 shows representative images of the hippocampus from each experimental group.*
   - *Within 72 h, representative cytokines, chemokines, and adhesion molecules had increased significantly (Fig. 4).*

The discussion

1) STRUCTURE: In the discussion, you need to explain the meaning of your results and to discuss what contribution they make to the existing evidence. Structure your discussion like an inverted funnel, the opposite of the introduction section (Fig. 2). Begin with one or two very specific sentences to answer the question posed in the introduction (A - Answer to the question); be sure to use the same key terms you used in stating the question in the introduction. It may be useful to precede the answer to the question with an introductory statement (one or two sentences, maximum)

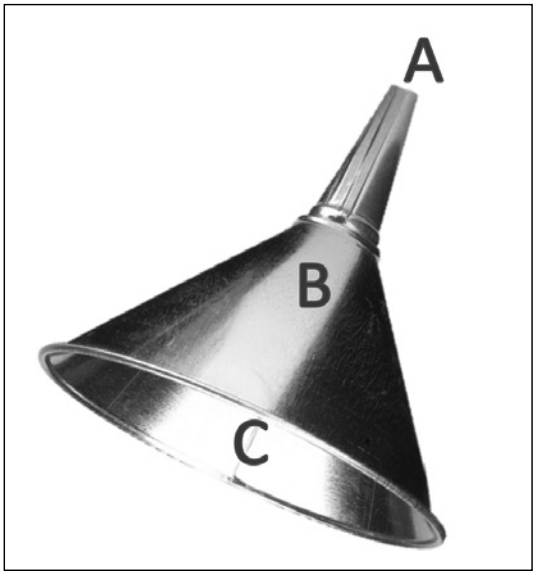

Figure 2. Organization and discussion. A) Answer the question. B) Interpretation and discussion of the results. C) Contribution of the study.

to add context to the section, since the introduction and the discussion are so far apart.

The next step is to explain how your results support your answer (B - Interpretation and discussion of results). The funnel should broaden as you discuss and interpret your results. You need to help readers situate your study in the literature and help them gain perspective on how your results fit in with what was already known. You should discuss whether your results are consistent with previously published studies, and if they are not, you should discuss why. It is important to mention the real and potential limitations of your study.

Finally, you need to emphasize the contribution your study makes to the field and its implications for future studies (C - Contribution of the study. Summary statement). It is crucial to end the article with a strong statement. Too often writers end on weak note with a cliché like "more studies are required to...". Instead, you should include a summary statement with a take-home message for the reader and a call for action if your conclusion allows it.

2) TENSE: The discussion is the section where the widest variety of tenses is used. These may include the past, present perfect, present, conditional, and even future tenses. Use the past tense when referring to what was done and the present for making conclusions. *We found that oxidative DNA damage and errors in repair DNA synthesis mainly contribute to rare spontaneous mutations; this suggests that...* Use the future tense to indicate future directions for research. *We will publish our final results next year. This approach will enable large samples to be screened.*

3) SIGNALING TOPICS: Useful language for signaling topics in the discussion section include:
   - *The results of this study show/indicate that...*
   - *This experiment did not detect any evidence for...*
   - *This study confirms that X is associated with...*
   - *However, the findings of the current study do not support the previous research.*
   - *The results of our study not only...*
   - *This inconsistency/discrepancy may be due to...*
   - *A possible explanation for this might be that...*
   - *Our results corroborate...*
   - *This finding is in line with that reported by Fulano et al.,[27] who reported that...*
   - *Unlike other groups,[16, 17, 31] we found no correlation between...*

Exercise 1

Decide whether these statements about the organization of an IMRaD paper are true or false.

1) Always begin your introduction with a specific statement of the goals of your study.
2) Your introduction needs to justify why you did your study.
3) Your introduction should provide as much background information as possible, including a minireview of the literature on your subject.
4) The methods section talks about what YOU did, so you should never cite other authors.
5) The experimental design of the study must be clearly explained in the methods section.
6) It is always strictly necessary to use the same subsections in both the methods and results.
7) Always provide full details about manufacturers and suppliers of equipment and materials.
8) The text of the results section should highlight information from tables and figures that is directly related to the objectives of your study.
9) You should never mention results that are not directly related to the objectives of your study, no matter how interesting they may seem.

Continue

10) Always use the same terms for key concepts in the methods and results sections.
11) The order of the columns and rows of a table are not important.
12) A thorough discussion should mention most studies that are related to yours in any way.
13) The discussion should never deal with "interesting" results of your study that are not directly related to your objectives.
14) You should be sure not to omit discussing any of your results in the discussion section.
15) Always end your discussion with some kind of conclusion.

Exercise 2

Put the sentences from this introduction in the most logical order.

Predictors of postoperative ARDS in patients undergoing non-high risk surgery

1) More than 30% of ARDS patients die before discharge.
2) Moreover, the influence of ventilator and fluid management on whether ARDS develops is unknown.
3) We hypothesized that patients with known risk factors for end-organ dysfunction receiving large volume resuscitation and nonprotective ventilator management would be more likely to develop postoperative ARDS.
4) The risk factors for postoperative ARDS in patients undergoing other types of surgery are not well defined.
5) We aimed to determine preoperative risk factors for ARDS in patients undergoing surgery other than cardiac, thoracic, vascular, or trauma surgery and to define the role of ventilator and fluid management in the development of postoperative ARDS.
6) Acute respiratory distress syndrome (ARDS) is defined as the rapid onset of hypoxia (Pa/FIO_2 ratio ≤ 300) and bilateral infiltrates in the absence of left atrial hypertension.
7) Patients undergoing cardiac, thoracic, vascular, or trauma surgery have increased risk of developing postoperative ARDS.

Exercise 3

Put the sentences from this materials and methods section in the most logical order.

Material and methods

1) We selected cases in which new-onset atrial fibrillation was detected at EKG or Holter monitoring.
2) We reviewed the medical histories of 150 consecutive patients admitted to our stroke unit between January 1, 2005 and December 31, 2005.
3) We also recorded the time from admission to detection of atrial fibrillation.
4) All patients underwent EKG and 80% also underwent Holter monitoring.
5) SPSS (v.10.2) was used for all statistical analyses.
6) We recorded the time from admission to Holter placement and the number of EKGs obtained within three days of admission.
7) Criteria for admission to the unit were noncomatose patients with cerebrovascular event suggested by clinical presentation and confirmed by neuroimaging with onset < 48 h who had no concomitant disease or disabling disorders that would limit their ability to undergo rehabilitation.
8) We excluded patients with intracranial bleeding.
9) We used Fisher's exact test to analyze the EKG data and the McNemar test to analyze EKG and Holter data in patients who were monitored with both techniques.

Exercise 4

Decide in which sections of an article the following statements would be most appropriate.

1) This report represents one of the largest single-institution series of patients with breast papilloma.
2) To evaluate agreement between methods, we used the Wilcoxon signed-rank test, Spearman correlation, and Bland-Altman analysis.
3) We sought to test whether ischemic lesion size on CT angiography depends on the CT angiography acquisition protocol.
4) Currently there are no objective clinical tools that can accurately discriminate aggressive from indolent prostate cancer.
5) To find the best parameter for channel design, we designed three channels of different heights: 10 µm, 50 µm and 100 µm.
6) Semen analysis was performed according to published guidelines of the World Health Organization.[6]
7) Further studies are required to elucidate the nature of a higher degree of polyunsaturation in the NMR-visible lipid pool upon eLDL loading.
8) After 4 weeks, plasma HDL-C in the SUB885C group was 39% higher than in the controls (1.1 ± 0.3 mmol/L versus 0.8 ± 0.3 mmol/L, $p < 0.05$).
9) TLX has been proposed to function primarily as a transcriptional repressor of target genes through its physical interactions with transcriptional corepressors including epigenetic modifiers like lysine-specific histone demethylase 1 (LSD1).[12-15]
10) Our findings corroborate reports that aprotinin administration increases the risk of postoperative AKI.[1,3,13-15]