

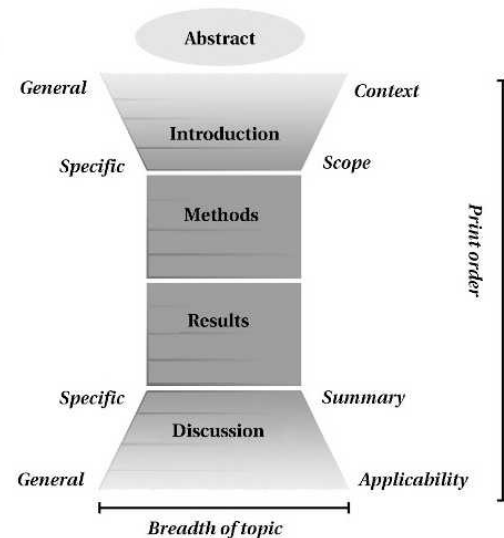
Biomedical research articles: structure guides the writing process

IMRaD structure

The research article in IMRaD format is a genre, i.e. a type a text with defined characteristics (e.g. structure, style, tone, content) that readers expect. Other examples of genres are review articles, meta-analyses. editorials and case reports. Knowing the features of a genre facilitates reading and enables us to produce text that meets readers' expectations.

IMRaD is an acronym that refers to the four main sections of a research article. Dividing the content of a research article in these four sections reflects the scientific method. IMRaD usefully separates what was known before from what is new, so it helps readers critically appraise a research article and helps us write one.

IMRaD is graphically depicted as an hour-glass shape in terms of the breadth of the topic as we go along the print order. Some journals position the Methods section after the Discussion, but this has little impact on the writing process.



Introduction Rhetorically, in this section we (i) define a research territory, (ii) establish a niche in that territory – the problem we observed, and (iii) occupy that niche by telling readers what the study aimed to do. In terms of content and structure, this section presents: (i) the research context (background); (ii) the latest research (state-of-the-art knowledge); (iii) the problem that motivated the study; (iv) the specific study objectives; and *only* in molecular areas of research (v) a brief summary of the findings.

Methods This section presents the materials and methods used in a study, and if needed it justifies the choice of methods. Importantly, it documents the adherence to research ethics. It also defines the criteria and cutoffs used in data analysis.

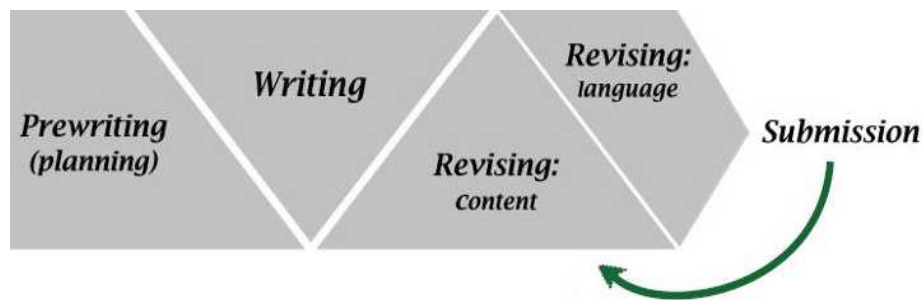
Results This is the heart of a research article. It is a narrative that guides the reading of the graphical displays (tables and figures). It is like a museum guide who presents paintings in a gallery.

Discussion Here, we (i) summarize the main findings, in a factual, dispassionate way; (ii) compare the new research with prior research (confirm? contradict? go beyond?); examine the limitations of our methodology and tell the extent to which our work can be applied in practice or our new knowledge can be generalized (to other patients, species, pathologies ...); and (iv) draw conclusions by synthesizing new knowledge.

The writing process

Prewriting (planning) – in three steps

1. We choose a set of experiments with enough results for 5–8 displays (tables and figures) that make a coherent argument. Each display represents an important stage of the study and gives a unique, valuable message. We prepare the displays in almost publishable form.



2. We give birth to our article by drafting: (i) a working title, (ii) a statement of study motivation (why we did it), and (iii) a statement of study objectives (what we aimed to do).
3. We choose one or more target journals, learn about these journals, and assemble a preliminary list of co-authors.

Writing We write *from the results out*. We begin with the Results section, as this is the easiest to write: the displays define what content to present and in which order, and the grammar is simple. When this section is complete, we know the content and order (the same!) of the Methods section. Only when these two core sections are complete are we ready to write the Introduction, which *introduces* the main actors (e.g. pathology, genes, drugs) of our study and prepares readers to receive our results. Next, we tackle the Discussion. We revise, revise, and revise again, and only then do we write an abstract. Doing this late ensures that the abstract reflects the final text, not an early draft.

Revising (content and language) Even with careful planning, as we write our ideas become clearer. We revise to increase the chances that our manuscript is accepted for publication. More importantly, we revise to improve the usability and reproducibility of our research. We can be our own editor: First, let time pass and reread after several days. Print, go to a quiet place and edit with a red pen. Read aloud and listen! Revise structurally to ensure that the IMRaD sections are distinct (not overlapping), complementary (not contradictory), similarly developed, and internally coherent: (i) the results are coherent with the study objectives; (ii) the Methods and Results sections correspond; (iii) the summary (Discussion section) responds to the study objectives; and (iv) the conclusions (Discussion section) respond to the study motivation.

Ready for submission!

We write a cover letter that personally addresses the journal's editor and makes a case for our manuscript. We submit only our best work (both research and writing) to avoid multiple rejections, revisions and resubmits. We aim high. Aim for immediate acceptance!

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