



Medical writing curriculum: how to write the methodology and results sections

Jeremy Dean Chapnick

Editorial Office, AME Publishing Company

Correspondence to: Jeremy Dean Chapnick. Editorial Office, AME Publishing Company. Email: amj@amegroups.com.

Abstract: The results and methods section of a research paper are the two most essential parts of all research papers. These sections clearly explain the procedures for conducting the research study and how all of the data was gathered. These two sections are critical in the scientific process because they allow other researchers to reproduce the experiment or if they want to assess the data or apply other models to produce different results. Therefore, it is critical for the scientific process to make sure that these are written well. This chapter will delve into what needs to go into both of these sections, and how to format them.

Keywords: Academic writing; methodology section; results section

Received: 23 May 2019; Accepted: 21 August 2019; Published: 02 September 2019.

doi: 10.21037/amj.2019.08.01

View this article at: <http://dx.doi.org/10.21037/amj.2019.08.01>

Part 1: why even care about writing a proper methodology and results section?

To begin with the methodology section (shortened as “methods”), this section is vital due to it providing other authors and readers a chance to judge how valid the study is at a glance. The methods section explains in detail how the data was gathered or obtained, and it also describes how the data was analyzed. The methods section is so critical because the readers need to know how the data was collected, as this knowledge may affect the results and how they are interpreted. In essence, the methods section could be considered the metaphorical “root” of the study, explaining how the study was conducted, and how the author came to their result.

Additionally, there are many ways a researcher can go about collecting data. The methods section gives the researcher a chance to explain the reasoning and other justifications behind the methodology choices used. Due to the methods being the “root” of the paper’s results and implications, this provides the author with an opportunity to combat future arguments against the validity of the study from the methods section alone. Therefore, the methods section can give the authors a chance to explain themselves to provide clarity to future readers. Establishing clarity and

transparency is crucial because it shows how the author anticipated issues within the study and how they were prevented.

Also, the methods section allows the authors to establish the standards for the study. The methods section provides the authors with an opportunity to show that the data was collected using the accepted clinical methods and standards for the practice. For example, if this was a study using a survey, was there an adequate sample size?

Besides establishing that the author followed scientific standards and clarifying the methods used, the methods section also provides the author with an opportunity to justify how the objectives of the study led to the results of the study.

Lastly, the most critical part of writing a proper methodology section is to allow the study to follow the scientific process. One core aspect of testing a theory using the scientific method is to repeat the research. The methodology section gives future researchers clear and concise instructions on how they may repeat the review, step-by-step. Therefore, future scientists and researchers will be able to repeat the methodology and verify the research.

The results section goes hand-in-hand with the methods section of the paper, and the methods used will directly

Methods: The algorithm for an IDR of $2.22 \text{ gl}\cdot\text{s}^{-1}$ was developed based on the relationship between VCE and contrast volume in 141 patients; test bolus parameters and characteristics in 75 patients; and, tube voltage in a phantom study. The algorithm was retrospectively tested in 45 patients who underwent retrospectively ECG-gated CCTA with a 100 kVp protocol. Image quality, TID and radiation dose exposure were compared with those produced using the 120 kVp and routine contrast protocols.

Methods: As preliminary tests indicated that out-of-the-box segmentation CNN U-net performance was compromised by close apposition of wrist tendons and bone, we separated the volumes prior to segmentation by using classification CNN Inception V3 to group images with similar features. The classified images were then segmented by individually trained U-net. We trained the networks on 40 cases and tested them on 11 cases derived from an MR imaging dataset of 51 patients with varying severity of ERA.

Figure 1 A few examples of methods sections from original articles published in the *Quantitative Imaging in Medicine and Surgery* Journal from AME Publishing Company (1,2).

impact the results. Typically, the results section will follow the methods section in sequential order, and due to their closeness in purpose, they share the same importance.

The core reason that a researcher should care about writing a good results section is that it provides the researcher with the opportunity to report about the findings of the study. It answers the core and fundamental question of, “what was found in the research?” The readers should be able to pick up the paper and be able to quickly read the results section to understand, at a glance, what exactly were the findings of the study.

The secondary reason why an author should care about writing a good results section is to provide future researchers and authors relevancy. The results section presents the authors with an opportunity to show the core findings that were derived from the methodology section that came before it.

To conclude, the methods section and the results section are critical parts of any research paper. They act as the metaphorical “root” of the study and are the entire basis of the research. It provides the readers with information about how the study was done, and what results were gained from the analysis. Without well-written methods and results sections, future researchers would be unclear about much of this information.

Part 2: how to write a methods section?

The main goal to keep in mind when writing the methods section is that the authors are trying to solidify their study’s validity in anticipation of potential criticism. Therefore, it is vital to write a clear and precise description of exactly how the study was performed. Future readers should be able to pick up the paper and understand what the research question was and how it was solved, follow the experimental design, and know how the results were analyzed.

Firstly, the methods section should describe what materials were used in the study. Then, it should clearly explain how the materials were prepared for the study. Next, the author should describe clearly the protocols that were used for the research. Afterward, it should explain how the measurements for the data were performed, and how calculations were done. Depending on the type of research, it may also be necessary to state the statistical tests that were required for the analysis of the data.

The goal of the methods section is to be direct. There are several pieces of information that need to be crammed into such a small part, so the best advice that can be given is to draft and make outlines first. Make a list of all the critical pieces of information that are necessary to repeat the study and put the items in chronological order. Once the outline and chronological ordering are completed, focus on how those elements can be put in an order that is clear and logical. Look specifically for measurements, protocols, and other kinds of descriptions. Following these steps can help produce a suitable methods section that is logical and well organized.

For an example of a well-written methods summary section in an abstract, please see *Figure 1*.

Inside the manuscript, the method section should utilize subheadings to divide up the different subsections. In a manuscript, the methods section should be divided into, “participants”, “materials”, “design”, and “procedure” (1).

Participants

In this section of the methods, it should clearly describe who or what was the subject of the experiment. Information like who the tested population were, how the tested population was chosen, and how many total participants were involved, should also be included. This is an example from “MR imaging dataset of 51 patients with varying

severity of ERA”:

Minimally, the methods must convey who was in the study, the population from where the participants came from, and any notable restrictions that are worth noting should be stated here. It should also explain how many participants were in the study, how many were assigned to each cohort, and any essential characteristics that are worth noting that could be of relevance to the study.

Providing this information helps other researchers understand how the study was done. It also helps to give the researchers information about how relevant the results might be. Also, it allows the researchers to repeat the research with other patient groups to see if they can get the same or similar results.

Materials

This section should describe in full detail all of the materials and equipment that were required in this study. Some examples include databases, testing instruments, books, and figures that were used during the study, for example, “We separated the volumes prior to segmentation by using classification CNN Inception V3 to group images with similar features.”

It is not necessary to list common, everyday items like pencils, pens, paper, and computers. Only recording any specialized equipment that would be necessary for reproducing the study is required. If a particular type of tool was created for this study, go into greater detail describing it, and it also might be helpful to provide a chart or illustration on the item so that it may be referred to if the study is to be repeated in the future.

Design

In this section, the author should describe the variables and how these variables impacted the study. Identify the dependent variables, the independent variables, the control variables, or any other variables that might have influenced the results of the research. For example, “We trained the networks on 40 cases and tested them on 11 cases.”

Procedure

In the procedure section, the authors should explain precisely how the experiment was conducted. Explain how the data was collected and at which steps data collection occurred. For example, “As preliminary tests indicated that

out-of-the-box segmentation CNN U-net performance was compromised by close apposition of wrist tendons and bone, we separated the volumes prior to segmentation by using classification CNN Inception V3 to group images with similar features.”

Do not overwhelm the reader with excessive or unnecessary steps and unnecessary information. Keep it simple and concise but also detailed enough. A balance should be made between being concise but also detailed.

Part 3: how to write a results section?

The results section should summarize the data that was collected and reveal the results of any statistical analysis performed in the study. The goal to keep in mind when writing the results section is to report on the results without giving any opinion or any subjective interpretation of the results that were received from the study; report the results as raw data.

In terms of general formatting and writing style, the results section should be written in the past tense (3). The goal is to be concise and objective, and it is not a time to be verbose. Each institution will have different formatting requirements for a results section; in APA formatting, the results section follows the methods section.

The results should try to end with justifying your claims. To achieve this, try to report the data in a way that can help defend your conclusions. However, the results section is not a section for subjective interpretation of the data; this interpretation is reserved for the discussion section; only focus on the hard, core data from the study. The discussion section and the results section go hand-in-hand, in that the data that is reported in the results section will be used as the baseline for all the information that will be written in the discussion section. Therefore, it would be easier to write the results section first to make sure that all of the data points are there.

It is also important to remember not to omit relevant findings. The results section should provide an entire look at precisely what was found in the study. Make sure to mention every piece of pertinent information that was found. It is imperative not to omit results that were found, just because they did not support the hypothesis. Do not ignore negative results. It does not mean the results are less important because they failed to support the hypothesis. Results that do not support the thesis could be just as informative and valuable.

Another thing to keep in mind when writing the results is

Results: Age, sex, body surface area (BSA) and peak contrast enhancement (PCE) were significant predictors for VCE ($P < 0.05$). A strong linear correlation was observed between VCE and contrast volume ($r = 0.97$, $P < 0.05$). The 100-to-120 kVp contrast enhancement conversion factor (E_c) was calculated at 0.81. Optimal VCE (250 to 450 HU) and diagnostic image quality were obtained with significant reductions in TID (32.1%) and radiation dose (38.5%) when using 100 kVp and personalized contrast volume calculation algorithm compared with 120 kVp and routine contrast protocols ($P < 0.05$).

Figure 2 The results section from a published research paper from AME's Journal *QIMS* (1).

to try to think of a way to make it as simple as possible. The results section should primarily be a summary of the data, and it should not include every single piece of data that was gathered in the study. The principle of inclusion should be how relevant the data is to answer the research question. If there is a lot of extra data that could be helpful, it is better to make a figure or a chart with the entire dataset to place somewhere else in the article for researchers to reference if they need it. In general, the results should be a summary, and be a brief overview of the findings, not a complete presentation of every single data point.

It is possible for tables and figures to be inserted into the results section of a paper. However, make sure that if a table or figure is added, the data contained within the illustrations or charts are discussed directly. Do not include any tables or graphs if they are never referenced in the results section. If a table or graph is inserted into the results section, a helpful organization tip to consider is to make the chart first, and then write about it afterward. That way, it is possible to organize the data logically, and then a summary to support the figure as text can be provided. If the information already appears in a chart, there is no need to repeat the same data, and it only needs to be talked about once.

One other important thing to keep in mind is that always assume that the readers have a basic understanding of how statistical data is collected. There is no need to define what a Chi-squared test is or what a *t*-test is, for example. Just report results. The job of the author is to present the results objectively, not to teach readers how to analyze and interpret statistics.

An excellent example to follow as a reference is supplied in *Figure 2*.

In *Figure 1*, the way the authors portray the results is objective, and they do not use any extra details or opinions. The authors only report on the raw data that was gathered in the study. Also, this is an excellent example because it summarizes the data that was collected and reveals the statistical analysis methods that were performed in the study. The authors also do an excellent job at being straightforward and clear, and each sentence details a new

piece of data that the researcher has found.

Acknowledgments

Funding: None.

Footnote

Provenance and Peer Review: This article was commissioned by the editorial office, *AME Medical Journal*, for the series "Medical Writing Corner". The article did not undergo external peer review.

Conflicts of Interest: The author has completed the ICMJE uniform disclosure form (available at <http://dx.doi.org/10.21037/amj.2019.08.01>). The series "Medical Writing Corner" was commissioned by the editorial office without any funding or sponsorship. Jeremy Dean Chapnick serves as a full-time employee of AME Publishing Company (publisher of the journal). The author has no other conflicts of interest to declare.

Ethical Statement: The author is accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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doi: 10.21037/amj.2019.08.01

Cite this article as: Chapnick JD. Medical writing curriculum: how to write the methodology and results sections. *AME Med J* 2019;4:33.