A Method for Teaching Biostatisticians to Write and Critique Specific Aims

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Abstract

This article describes the design of a single instructional module on writing and critiquing the Specific Aims (SA) section of a grant proposal for a biomedical research study. It begins by discussing the goals and learning objectives for the module. Then, it discusses the typical structure of a SA section to orient readers to the core content. This method is rooted in using an established framework for scientific writing, which is presented in brief, along with examples of how it applies to writing the SA section. Then, the structure of the instructional module is described, including the exercises for participants. Finally, the utility of this approach for teaching an otherwise difficult-to-teach competency is discussed, as well as how this approach might be extended to similar pedagogic tasks.

Keywords: grant writing, specific aims, collaborative biostatistics

1. Introduction

The effective practice of biostatistics requires mastery of multiple competencies (Pomann et al., 2020, Satagopan & Mazundar, 2021). Some of these involve concrete tasks, for example, writing appropriately documented R code to perform a linear regression. Other competencies are less tangible: for example, selecting an analysis strategy, designing studies, communicating findings to non-statistical investigators, etc. Concrete competencies are generally easier to define, learn, teach, and evaluate, so academic training tends to focus on them. An implication of this is that the skill sets of novice biostatisticians are often skewed toward concrete competencies. Nevertheless, developing less tangible, and often more general, competencies is critical to the novice's effectiveness and advancement. Thus, developing methods for teaching these competencies is an important subject of research in biostatistical pedagogy (Pomann et al., 2020, 2022).

Less tangible competencies are often learned through observation and mentoring. This learning process may start during academic training, such as internships, and continue on the job. A significant challenge is scalability: it is more efficient to mentor in a 1-many setting than 1-1, and it is more efficient to develop reusable teaching materials instead of starting from scratch for each training opportunity.

We encounter the question of teaching general and less tangible competencies to novice biostatisticians in two contexts. First, as directors of a Master of Biostatistics (MB) program that aims to move beyond training in concrete competencies, we are responsible for curriculum development (Neely et al., 2022; G. Samsa, 2021; G. P. Samsa, 2018, 2020; G. P. Samsa et al., 2018; Troy, Granek, et al., 2022; Troy, McCormack, et al., 2022). Second, as directors of a Biostatistics, Epidemiology, and Research Design (BERD) Core embedded within a department of biostatistics and bioinformatics, we are responsible for hiring and developing systematic training curricula for both novice and experienced biostatisticians to improve their skills (Desai et al., 2022; Hanlon et al., 2022; Pomann et al., 2022).

Here, we describe one element of an ongoing program of professional development within our BERD Core, designed with the above resource constraints in mind, and focusing on a general competency necessary for the successful practice of biostatistics in an academic medical center or comparable research environment: writing and critiquing a

specific aims (SA) section of a grant proposal. The general competency being addressed is the component of effective communication that summarizes information about a proposed research study. The primary audience for this training is the staff in our BERD Core, although we propose that the same training can be applied more broadly, including to students training in statistical sciences at the master's or PhD level.

In this article we describe the design of a single instructional module on writing and critiquing the SA section of a grant proposal for a biomedical research study. It utilizes insights from the literature on a related but separate topic: namely, how to teach principal investigators to write the SA section of a grant proposal (Birmingham, n.d.; Freel et al., 2017; Harvard Clinical and Translational Science Center, n.d.) There, the focus is on presenting the underlying science in a fashion that is transparent and persuasive to others. Here, instead, the primary goal is effective communication about that science within an interdisciplinary team, especially the statistician's role in facilitating that communication. Thus, the most relevant literature pertains to experience in teaching communication-related competencies to biostatisticians (e.g., refs), using a constructivist perspective (Matthews, 1993).

We begin by discussing the goals and learning objectives for the module. We then discuss the typical structure of a SA section to orient our readers to what we are teaching. Our method is rooted in the use of an established framework for scientific writing (Gopen & Swan, 1990), which we present in brief along with examples of how it applies to writing the SA section.. Then, we discuss the structure of our instructional module, including the exercises for participants. We close with a reflection on the utility of this approach for teaching an otherwise difficult-to-teach competency and discuss how our approach might be extended to similar pedagogic tasks.

2. Instructional Methods

2.1 Terminology

Mastery of writing and critiquing the SA section of grants could potentially be termed a "skill" or a "competency", the latter representing the more general construct (Parry, 1998; Woodruffe, 1993). Because writing and critiquing a SA section requires multiple skills, we have chosen to use the term "competency" as a sub-construct nested within "communication".

2.2 Goals and Learning Objectives

The primary goal of the SA module is to help participants improve the quality of their collaboration around the SA section of grants (*Draft Specific Aims*, 2020; Monte & Libby, 2018). For example, understanding the SA is critical for designing an appropriate statistical plan, as discussed elsewhere (Troy et al., 2021). Improving the quality of collaboration around SA involves (1) a systematic method for reading, summarizing and critiquing a SA section; and (2) directed practice in writing statistical elements of a SA section.

All biostatisticians, whether experienced or novice, need to be able to understand a SA section. More experienced practitioners may be asked to write elements of a SA section. Accordingly, the focus of the module is primarily on systematic reading and secondarily on writing. However, rewriting a problematic SA section into a more standard format is a useful tool for critiquing, and thus writing exercises are offered to everyone. A secondary goal of this module is to introduce a framework which participants can use as a general tool to improve their scientific writing.

The module as we present it here is meant to be executed in real time with an instructor facilitating the session for a small audience. Alternatively, the didactic elements of the module could be turned into pre-recorded videos that enable self-study of the material.

2.3 Organization of a Specific Aims Section

A SA section is effectively a self-contained executive summary of a proposed project, usually 1 page in length and intended to answer, among others:

- What is known about the topic being studied?
- What is unknown about the topic being studied?
- What is the study question?
- Why is the study question important?
- What are aims of the study?
- What are key elements of the study design?
- Why is this study worth supporting?

At our institution, systematic training for investigators around writing SA sections is embedded within a workshop (Freel et al., 2017) and a specific template for writing which answers the above questions, in order. Some typical advice includes the following:

- In describing what is known about the topic being studied, explicitly make connections that might be obvious to an expert.
- Don't tell the reader everything you know. What is known about the topic being studied should set up what is unknown and, thus, the study question.
- Link aims and key elements of the study design. As per the main review criteria in a Study Section, the reader must be convinced about the significance of your study question and that your approach to answering it is sound. Minutia are discouraged, but if possible the key hypotheses and/or statistical techniques should be briefly described.
- Conclude with a "payoff paragraph" which explains why the world will be a better place if the proposed research is successful.

3. Conceptual Framework for Scientific Writing

Our approach to teaching scientific writing is based on the work of Gopen and colleagues (Gopen & Swan, 1990; Gregory Samsa & Oddone, 1994). In essence, this framework asserts that that readers have (perhaps unrecognized) expectations about the ideal format which a unit of discourse should have. Moreover, it asserts that reader burden can be minimized by (1) utilizing this expected format; and (2) always placing information into context by preceding "new information" with "old information" (Gopen & Swan, 1990). Because of the large amount of complex information which it transmits, scientific writing is especially susceptible to reader burden.

This approach holds that a hallmark of effective scientific writing is the act of moving the tacit knowledge of a substance-matter expert out of the expert's head -- a place which is only useful to the writer -- onto the printed page -- and thus useful to the reader as well. Making those linkages which are clear to an expert but not necessarily to others explicitly serves this purpose. The benefits of explicit linkage also extend to those who are learning the content in question. Indeed, unclear writing often reflects imprecise thinking, for which "writing to learn" is a natural remedy (Holliday et al., 1994).

Throughout this section, our focus is on the structure of scientific writing rather than its content. Accordingly, the examples are general (and, for example, do not describe a specific SA section focusing on a specific scientific issue).

3.1 Application to SA Section as the Unit of Discourse

At the unit of the SA section, the conceptual framework described above not only represents a logical progression of ideas, but it also illustrates preceding new information with old information. For example, when considering what is unknown about the topic being studied, the old information about what is known places it into context.

3.2 Application to Paragraphs as the Unit of Discourse

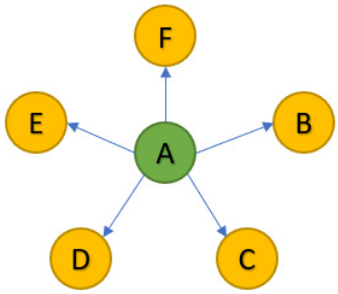

Figure 1. A Story About 'A'

At the unit of the paragraph, two structures illustrating these principles are "a story about A", and "a cascade". In "a story about A" (Figure 1), the flow of the sentences is: (1) A -> B; (2) A -> C; (3) A -> D; (4) A -> E; (5) A -> F (where the arrows are read as "points to"). For example, in the first sentence, A denotes old information covered previously in the larger unit of discourse, B denotes new information and the arrow (->) denotes that the old

information is pointing to the new information. This paragraph structure provides an excellent way to discuss multiple implications of A.

Description: The nodes in the diagram represent sentences in a paragraph with A being the first sentence, B being the second sentence, etc. The arrows are read as “points to”. Because all arrows emanate from A, this indicates that the sentences B through F are telling a story about the concept discussed in sentence A.

In "a cascade" (Figure 2), the flow of the sentences is as follows: (1) A -> B; (2) B -> C; (3) C -> D; (4) D -> E; (5) E -> F. The paragraph flows to the conclusion "F", and each sentence serves to provide context for the next.

Figure 2. A Cascade From ‘A’ to ‘F’

Description: In this paragraph structure information flows from the first sentence, A, to the concluding sentence, F. Each intervening sentence (B through E) points from old information to new information.

Of course, not every paragraph in a scientific communication need be structured as above. Nevertheless, model structures can prove useful. For example, to successfully create a paragraph in a cascade structure, the writer must understand the flow of cause and effect within each sentence, and also be able to explicitly describe the linkage between the two. These model structures can also be combined. For example, this structure begins as a cascade illustrating the importance of D and then shifts to a story about D: (1) A -> B; (2) B ->C; (3) C -> D; (4) D -> E; (5) D -> F; (6) D -> G.

3.3 Application to Sentences as the Unit of Discourse

At the unit of the sentence, this framework not only recommends starting by restating old information and ending with new information, but by utilizing punctuation as a structural clue: in its terminology, the word or phrase directly preceding the punctuation mark is in the "stress position" and represents new information. Accordingly, the ideal sentence begins with old information, contains new information in the stress position, and has an explicit link between the two. Complex ideas can be expressed by dividing sentences into pieces (i.e., sub-units), with each sub-unit separated by a punctuation mark.

3.4 Examples

Unlike some other forms of writing, scientific writing should be at least somewhat redundant. The purpose of this redundancy is to reassure the reader that they haven't become lost, because if they feel lost they'll spend energy worrying about that instead of trying to understand what you've written. Repeating old information provides the desired redundancy.

As an example, consider the following two sentences, which are part of a discourse about scientific writing and that we have diagrammed with bold text and underlining.

> **Scientific writing** should be at least somewhat redundant. The purpose of this **redundancy** is to reassure the reader that they haven't become lost.

This example shows that scientific writing begins with old information, indicated by bold text. The new information in the sentence, located just before the period and indicated by underlining, is redundant. For the next sentence, this redundancy becomes old information (in bold) and the new information is that readers don't want to feel lost (in underlining).

More complex ideas can be expressed using multiple items of punctuation. Consider the following example.

> The purpose of this **redundancy** is to reassure the reader that they haven't become lost, because if they **feel lost** they’ll spend energy worrying about that instead of trying to understand what you’ve written.

As with the original example, redundancy is old information (in bold) and the new information pertains to the lost readers (underlined). In this new example, as the sentence continues the lost readers become old information (“feel lost” now being diagrammed in bold) and “worrying about that…” (underlined) becomes the new information. In other words, the ideas in the first and second half of the sentence are interrelated.

In our instructional module on writing specific aims we use the above method to both deconstruct and critique SA that are already written, and to practice writing new specific aims.

4. Structure of the Course Module on Specific Aims

The structure of the module is illustrated in Figure 2 and is described as follows.

1. In a lecture presentation:
    a. Define SA and discuss their purpose as an executive summary for the grant proposal that establishes the rationale for the approach to study design, data collection, statistical analysis, and reporting of the results.
    b. Present the general model of scientific writing (see Section 3 above) and discuss its application to writing SA using an example clinical trial of an intervention to treat motor function deficits in cerebral palsy.
2. As a group exercise led by the instructor:
    a. Deconstruct a written SA page with the objective being to identify the following information in the writing sample:
        i. What is known about the scientific problem the research proposes to study
        ii. What is unknown about the topic
        iii. The research question being asked in the proposal
        iv. The importance of asking the question (e.g., to the scientific community, to patients, to public health, etc.)
        v. The statement of the SA themselves
        vi. Key elements of the study design
        vii. Why the study should be funded
3. Participants work in a group together (with assistance from the instructor as needed) to write their own SA page based on background information provided to them from a hypothetical discussion with a non-statistician collaborator who wants to write a research proposal.

The lecture slides and script for items 1 and 2 are included in Appendices A and B, and the worked example based on the clinical trial in children with cerebral palsy is given in Appendix C. Note that much of the material in item 1 could be recorded for viewing outside the classroom prior to attending an in-person session where the example based on the cerebral palsy intervention in item 2 is discussed as a group.

The exercise mentioned in item 3 (see Appendix D) asks participants to write their own SA page based on a proposed clinical trial of a smoking cessation intervention in smokers with serious mental illness. The key challenges in this assignment, aside from applying the model of scientific writing to crafting a SA page, are to recognize that some of the background information provided by the non-statistician collaborator is either:

1. Useful for writing the SA page; or
2. Unclear and of questionable relevance to the SA page; or
3. Irrelevant for writing the SA page; or
4. Some relevant content required for writing the SA page is missing.

Therefore, part of the exercise is to start by writing a list of clarifying questions that might be asked of the non-statistician collaborator prior to writing the SA page. For purposes of the exercise, the instructor plays the role of this non-statistician collaborator and answers the participants' questions.

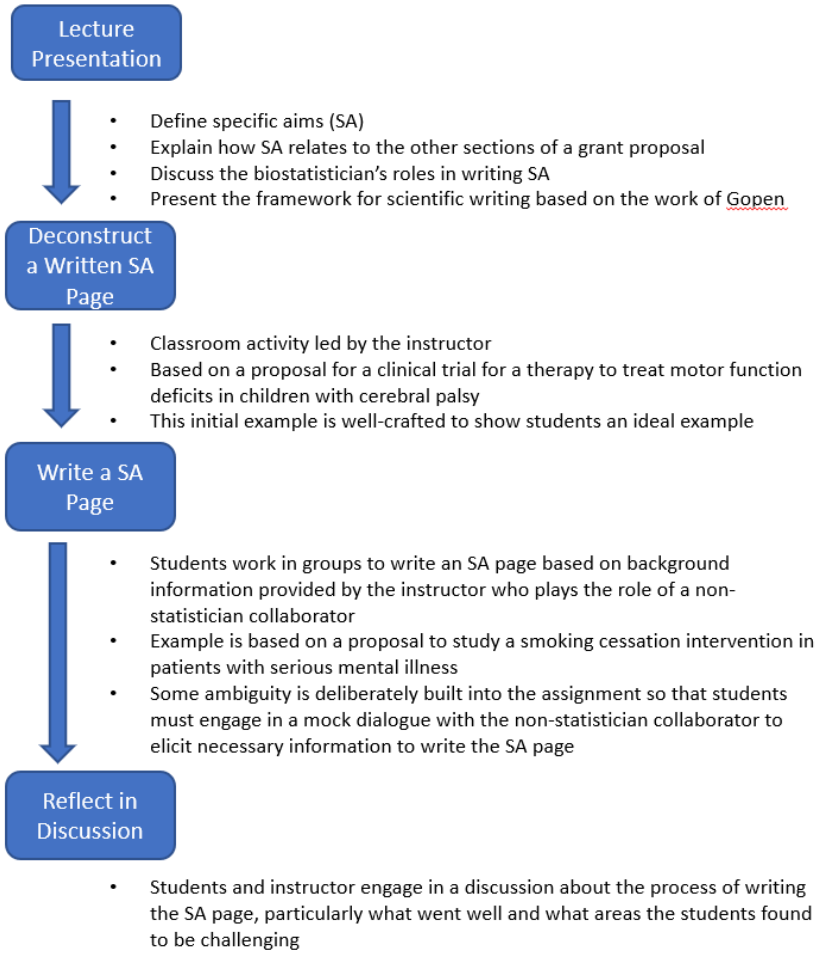

Figure 3. Diagram of the Course Module on Specific Aims

5. Discussion

We have described a structured, conceptually driven, active-learning approach to teach novice biostatisticians how to master the specific aims section of a grant proposal. This SA module is one of multiple such modules whose goal is to assist novice biostatisticians in developing and improving various high-level competencies. Such competencies differentiate expert practitioners from novices and are key to effectiveness on the job, but it remains unclear how they can be most effectively taught. A challenge in teaching is that while the competency of writing and critiquing SA is clearly defined, it is not entirely concrete. Unlike using a mathematical formula, there is no one definitive approach to applying it. Writing an effective SA page involves art in addition to science, yet we are nevertheless confident that this type of content is amenable to systematic instruction.

Our experience with other high-level competencies, use of strong statistical voice, for example, highlights the importance of operationally defining the underlying construct and the choice of use case (Pomann et al., 2020). Here, writing a SA page is a use case for broader constructs such as "summarizing information about the key aspects of a research project" and "communication", this latter construct being so broad as to be unactionable. A use case should be generalizable: for example, if a novice can master summarization within the context of a SA page, they should be able to extend that skill to summarize key aspects of a research project in other contexts as well.

In addition to being generalizable, a use case should be "teachable", which in turn implies that it can be partially translated into a rubric, a roadmap, or similar entity. Consistent with a constructivist perspective, our educational task can be understood as translating the mental maps which expert practitioners apply into materials that are explicit and actionable (Matthews, 1993). One such mental map pertains to the questions which a SA page should answer as well as the order by which they should be addressed. Indeed, in developing this module we substantially relied upon our experience in offering courses in grant writing to non-statistical investigators which utilized this format (Freel et al.,

2017). There, translating their specific aims into a consistent format facilitated review of the underlying science, for example, fine-tuning the study rationale. When adapting this approach for novice biostatisticians, the focus was changed from nuances about critiquing the science to clarifying the communication around the science, whose success is a necessary condition for the biostatistician to be effective. There is relatively little literature on how biostatisticians can effectively communicate about science, and none to our knowledge about how a SA page can be used to enhance this communication. Our previous experience provided confidence that the basic pedagogic idea described here ought to successfully be translated into the present application.

Another mental map is a simple and actionable deconstruction of the structure of scientific writing, which codifies some of the expert knowledge of researchers in this field (Gregory Samsa & Oddone, 1994). This mental map is based on a core principle, namely that the writer's task is to make implicit knowledge explicit by utilizing a structure that clarifies content and minimizes reader burden. Applying this mental map requires that constructs be accurately defined, and the relationships between them explicitly described. The resulting text helps identify what the novice biostatistician does and does not understand deeply, and thus can focus limited mentoring time. This core principle is effectively the same sound premise behind "writing to learn" (Holliday et al., 1994).

In summary, we believe that competencies such as the ability to write and critique SA are both valuable and teachable. A way forward can be based on reflecting on how experts approach the task, codifying the essence of what experts do, and then creating instructional materials around that. Indeed, an important step to becoming an expert is thinking like one.

6. Conclusion

Even though the ability to communicate around a SA page is a high-level construct that is not fully concrete, it is amenable to systematic instruction. The approach illustrated here, which is built on the constructivist premise of explicitly describing mental maps used by experts, providing illustrations of those mental maps and then directed practice in using them, shows promise.

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Appendix A

Lecture Slides

What is the specific aims (SA) page?

- 1 page
- Executive summary of a grant proposal
- Forms the basis for study design, the statistical analysis plan, etc.

1

What are we asked to do?

- Use the SA (everyone)
- Critique the SA (everyone)
- Write elements of the SA (experienced practitioners)

2

What will we practice?

- Identifying the main elements of information
- Rewriting a less than ideal SA page into a standard format
  - This, in turn, will put you in a position to effectively use it

3

Conceptual framework

- Standard elements of a SA section
- General model of scientific writing (Gopen)

4

Questions to answer (in order)

- What is known?
- What is unknown? What is the study question?
- Why is the study question important?
- What are the aims?
- What are key elements of the study design?
- Why is this study worth supporting?

5

Example

- Cerebral palsy (CP) is a leading cause of disability among children. CP typically results from a brain injury at birth or in utero. This brain injury has, until the present, been considered to be non-reversable, and so treatment is not curative, but instead is intended to help the child in question effectively use whatever level of physical function remains.
- A promising new approach to CP treatment is cord blood therapy, which is a form of regenerative medicine whose rationale is to use the stem cells located in cord blood to encourage regrowth of injured sections of the brain. We (and others) have demonstrated such regrowth in cell and animal models, thus demonstrating biological mechanism. Moreover, in a recent phase 2 placebo-controlled trial we have demonstrated that intervention patients had greater numbers of circulating stem cells than placebo controls 3 days after injection, and also that no adverse events were associated with these injections. This trial was not powered to detect efficacy outcomes, although we did notice greater improvement in motor function among intervention patients than controls for some aspects of physical functioning (not statistically significant). These preliminary results are encouraging, and set the stage for asking, in a more definitive fashion, what are the clinical benefits of CBT in CP.
- Thus, we propose a randomized, placebo-controlled, parallel-group randomized trial comparing CBT to placebo in C, aged 3-7 years, with moderate-to-severe disability due to CP. The sample size is 380 per group, and is powered to detect small effect sizes which are nevertheless clinically important.
- The aims are:
  - Aim 1 (primary): Compare the study groups on the C_P_FUNC scale, a validated measure of functioning in CP developed by G Clinton and colleagues in another context and modified for CP. The analytical method is a 2-sample t-test.
  - Aim 2 (secondary): Compare the study groups on quality of life using a validated parent-reported measure. The analytical method is a 2-sample t-test.
  - Aim 3 (exploratory): Assess whether the impact of the intervention differs between children with moderate versus severe disability. The analytical method is a test for interaction within a model containing study group, initial disability, and an interaction between the two.
- If successful, this study will be important because it will represent the first approach to successfully treat CP, rather than simply managing its symptoms.

6

What is known?

- Cerebral palsy (CP) is a leading cause of disability among children. CP typically results from a brain injury at birth or in utero. This brain injury has, until the present, been considered to be non-reversable, and so treatment is not curative, but instead is intended to help the child in question effectively use whatever level of physical function remains.
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  - Aim 1 (primary): Compare the study groups on the C_P_FUNC scale, a validated measure of functioning in CP developed by G Clinton and colleagues in another context and modified for CP. The analytical method is a 2-sample t-test.
  - Aim 2 (secondary): Compare the study groups on quality of life using a validated parent-reported measure. The analytical method is a 2-sample t-test.
  - Aim 3 (exploratory): Assess whether the impact of the intervention differs between children with moderate versus severe disability. The analytical method is a test for interaction within a model containing study group, initial disability, and an interaction between the two.
- If successful, this study will be important because it will represent the first approach to successfully treat CP, rather than simply managing its symptoms.

7

What's unknown? What's the study question?

- Cerebral palsy (CP) is a leading cause of disability among children. CP typically results from a brain injury at birth or in utero. This brain injury has, until the present, been considered to be non-reversable, and so treatment is not curative, but instead is intended to help the child in question effectively use whatever level of physical function remains.
- A promising new approach to CP treatment is cord blood therapy, which is a form of regenerative medicine whose rationale is to use the stem cells located in cord blood to encourage regrowth of injured sections of the brain. We (and others) have demonstrated such regrowth in cell and animal models, thus demonstrating biological mechanism. Moreover, in a recent phase 2 placebo-controlled trial we have demonstrated that intervention patients had greater numbers of circulating stem cells than placebo controls 3 days after injection, and also that no adverse events were associated with these injections. This trial was not powered to detect efficacy outcomes, although we did notice greater improvement in motor function among intervention patients than controls for some aspects of physical functioning (not statistically significant). These preliminary results are encouraging, and set the stage for asking, in a more definitive fashion, what are the clinical benefits of CBT in CP.
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8

What is the study design?

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9

What are the study aims?

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10

Why fund this study?

- Cerebral palsy (CP) is a leading cause of disability among children. CP typically results from a brain injury at birth or in utero. This brain injury has, until the present, been considered to be non-reversable, and so treatment is not curative, but instead is intended to help the child in question effectively use whatever level of physical function remains.
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11

A typical SA page

- Lots of people smoke. A significant number of people have major mental illness. Smoking decreases life expectancy. A cost-effectiveness analysis demonstrates that smoking decreases life expectancy among patients with major mental illness by 25 years on average. This analysis used a societal perspective, a dollars per life years saved framework, with a 6% discount rate, although other approaches might have been used instead. Patients with major mental illness tend to miss appointments and also tend to not follow their prescribed protocols. They are underrepresented in research, and we can't assume that results from other populations apply to them. We plan to perform a randomized trial, using an attention control group, where patients with major mental illness are presented with 2 versions of an app, one of which is gamified and the other isn't, and will analyze quit rates at 1 week, 4 weeks, 12 weeks and 26 weeks, number of cigarettes smoked during those time periods, intention to quit smoking, self-efficacy, suicidal ideation and quality of life.

12

Your task

- Eventually rewrite the SA page
- For now, classify the content by question (e.g., what are the study aims)
  - Some of the content will be useful
  - Some of the content will be unclear
  - Some of the content will be irrelevant
  - Some important content might be missing
- Then, prepare a list of clarifying questions to ask the investigators

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Writing tips

- Sentences
  - Begin with old information, explicitly link to new information, with new information placed directly before a punctuation mark
    - Scientific writing is about making implicit links explicit
- Paragraphs
  - Consider a story about A, a cascade, or a combination of the two
    - Story: A->B, A->C, A->D
    - Cascade: A->B, B->C, C->D
    - Combination: A->B, B->C, C->D, C->E
- Document
  - Follow a standard format, expected by your reader, in this case covering the questions which a SA page should answer

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Appendix B

Script for the Lecture in Appendix A

Slide 1

The specific aims page is, in effect, the executive summary of a grant proposal. Everyone benefits from understanding the specific aims -- for example, these form the basis of the statistical analysis plan.

Slide 2

What everyone should be able to do with a specific aims page is understand it, critique it, and use it (for example, to help write a statistical analysis plan). During the study design process, more experienced practitioners might be asked to write components of the specific aims section.

Slide 3

We'll practice two things. First, diagramming a SA page to identify the main elements of information which it contains. Second, rewriting a less than ideal SA page into a standard format. This rewriting process will include a simulated conversation with an investigator.

Slide 4

This module is based on two conceptual frameworks. The first framework is the elements of a SA page, and is the primary focus. The second framework is a general model for scientific writing, popularized at Duke by George Gopen from the English department, which we'll introduce in passing as a tool which many people have found to be helpful in improving their scientific writing.

Slide 5

A SA page should cover the following, more or less in chronological order. What is known about the topic under study? What is unknown? Between these two, this should motivate what is the study question? It should also motivate why the study question is important. The study question might first be posed as a general scientific question, but in order to be actionable it requires greater specificity. That’s where the study aims, differentiated between primary, secondary and exploratory come in. Then, key elements of the study design, which demonstrate that the study can accomplish these aims. Finally, a sales pitch about how the world will be a better place if the study is funded.

Before commenting on these various elements, let's work through an example.

Slide 6

Here's an example SA page, in really small font in order to fit within a single slide. We wrote the scientific part in lay English -- an actual investigator would probably use more technical language.

Slide 7

This slide highlights what's known, which is a natural way to begin a SA page. Investigators sometimes waste space by trying to write down everything they know. However, in a SA page what's known is only being used to contextualize what isn't known, which is actually the more important of the two.

Slide 8

This slide highlights what's unknown, which then sets up the study question, which in turn will carve out some of that unknown. The study question is often framed as a general scientific question, to be given greater specificity later.

Slide 9

The study design and aims are usually next to one another, as they are closely related. In other words, the study ought to be designed in a way that accomplishes the study aims which, indeed, is something that a grant reviewer will be checking for. Sometimes the design comes before the aims and sometimes it's the other way around. This SA page happens to have the design first. There's only enough space to hit the high points.

Slide 10

This slide highlights the study aims. As per the usual practice, they're divided into primary, secondary and exploratory. Sometimes there's space for a sentence or two about statistical analysis, as illustrated here, but you shouldn't overdo this unless the purpose of the project is to develop a new analytical technique.

Slide 11

Excellent practice ends with a sales pitch, essentially describing how the world will be a better place if this study is funded. That's highlighted here.

Slide 12

Your assignment will be to make sense of this draft SA page.

Slide 13

More specifically, you will eventually be asked to either rewrite it in a standard format, or alternatively to restructure the content as answers to the set of questions we've just illustrated -- for example, you'll need to answer what's known, what's unknown, and so forth. Some of the content is useful as stated and some is problematic, as noted on the slide. Your first task is to get as far as you can in answering the key questions, to highlight what's unclear or missing, and prepare a set of clarifying questions for the investigators to answer. During our in-person session we'll play the role of the investigators, answer your clarifying questions as best we can, and then leave you to rewrite the SA page in small groups. At the end of the session we'll compare your results, which ought to be interesting.

Slide 14

As background for the exercise, this slide provides some tips about effective scientific writing. These are based on the work of George Gopen and colleagues, and the accompanying document provides additional detail and a reference. The first example illustrates their use, at least within our limitations as a writer.

Appendix C

Worked Exercise for the Cerebral Palsy Example from the Lecture in Appendix A

C.1 Background Text for the Exercise

Note: The highlighted text corresponds to the answer key for the exercise questions below.

Cerebral palsy (CP) is a leading cause of disability among children. CP typically results from a brain injury at birth or in utero. This brain injury has, until the present, been considered to be non-reversable, and so treatment is not curative, but instead is intended to help the child in question effectively use whatever level of physical function remains.

A promising new approach to CP treatment is cord blood therapy, which is a form of regenerative medicine whose rationale is to use the stem cells located in cord blood to encourage regrowth of injured sections of the brain. We (and others) have demonstrated such regrowth in cell and animal models, thus demonstrating biological mechanism. Moreover, in a recent phase 2 placebo-controlled trial we have demonstrated that intervention patients had greater numbers of circulating stem cells than placebo controls 3 days after injection, and also that no adverse events were associated with these injections. This trial was not powered to detect efficacy outcomes, although we did notice greater improvement in motor function among intervention patients than controls for some aspects of physical functioning (not statistically significant). These preliminary results are encouraging, and set the stage for asking, in a more definitive fashion, what are the clinical benefits of CBT in CP.

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If successful, this study will be important because it will represent the first approach to successfully treat CP, rather than simply managing its symptoms.

C.2 Questions and Answer Key

Question 1: Find the study question.

Answer: the study question is highlighted in gray.

Question 2: Find the argument for why the study question contributes to knowledge. (Note that the intention isn't to tell the reader everything that the investigator knows but, instead, use what's known to place the study question into context.) More specifically, find what is known. This should lead to what is unknown: that is, the study question.

Answer: This SA page has a terse description of what is unknown and a more detailed description of what is known. This latter description is highlighted in blue.

Question 3: Find the aims. Classify these as primary, secondary and exploratory.

Answer: This SA page classifies the aims in addition to listing them. They are highlighted in yellow.

Question 4: Find the study design.

Answer: the study design is highlighted in green. It immediately follows the statement of the study question.

Question 5: Find the analytical methods.

Answer: the analytical methods are embedded within the aims, and are highlighted in purple. This illustrates the level of detail that can be reasonably achieved.

Question 6: Find the payoff paragraph.

Answer: the payoff paragraph is underlined.

Question 7: Using the slide on "writing tips" as an example, diagram the first paragraph. For example, label sentences as A, B, C, etc. and draw arrows between sentences that have ideas that “point to” others. You should find that the diagrams represent one or more of the 3 patterns of ‘story’, ‘cascade’, or ‘combination.’

A = CP

B = major cause of disability among children

C = caused by brain injury

D = non-reversible injury

E = treat symptoms rather than underlying cause

Answer:

A -> B

A -> C

C -> D

D -> E

Appendix D

A Less Coherent Specific Aims Page

D.1 Background Text for the Exercise

Lots of people smoke. A significant number of people have major mental illness. Smoking decreases life expectancy. A cost-effectiveness analysis demonstrates that smoking decreases life expectancy among patients with

major mental illness by 25 years on average. This analysis used a societal perspective, a dollars per life years saved framework, with a 6% discount rate, although other approaches might have been used instead. Patients with major mental illness tend to miss appointments and also tend to not follow their prescribed protocols. They are underrepresented in research, and we can't assume that results from other populations apply to them. We plan to perform a randomized trial, using an attention control group, where patients with major mental illness are presented with 2 versions of an app, one of which is gamified and the other isn't, and will analyze quit rates at 1 week, 4 weeks, 12 weeks and 26 weeks, number of cigarettes smoked during those time periods, intention to quit smoking, self-efficacy, suicidal ideation and quality of life.

D.1 Exercise (answers not provided)

Read the background text above, which is intended to simulate a communication from a non-statistician investigator you are working with. This investigator wants to write a specific aims page for a grant proposal. For purposes of this assignment, your instructors will play the role of the investigator and attempt to answer your questions. After hearing their answers, translate the text above into a standard format for a SA page. As you go through this process think about any clarifying questions that you might need to ask the investigator in order to translate the SA section into standard format. Recognize that you are likely to eventually get stuck trying to complete the assignment. Get as far as you can and we will discuss your response with the rest of the class.

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Data sharing statement

No additional data are available.