

Validating a Resource for the Specific Aims Section in NIH Grant Proposals

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ABSTRACT

The Specific Aims section in a National Institute of Health (NIH) grant proposal is considered the most influential part of the document, yet there are limited resources for researchers to utilize as guidelines for writing this section. This study extracts recommendations provided in a publication and compares them to samples of Specific Aims sections within successful grant proposals. The resource is discovered to reliably reflect the content within successful grants, and is thus concluded to be a reliable document that young researchers can utilize when writing their grant proposals to ensure success.

1. Introduction

Practitioners studying cancer treatments within the field of biology often rely on NIH research grants to gain funding for their projects, but one of the most challenging aspects of these grant proposals is the Specific Aims section. Although it is considered the most persuasive element for grant committees, there are limited resources on how to write this section and an article that presents detailed instructions for how to write one may raise questions of its validity.

This study examines the Specific Aims section of various successful NIH grants submitted to the National Cancer Institute to evaluate the validity of the information presented within a guide on writing these documents to provide researchers with a reliable resource that can assist them in successfully obtaining grants.

2. Methodology

For this project, I extracted guidelines and recommendations for grant proposals from one main source: "Introduction to the Specific Aims Page of a Grant Proposal" by Michelle Swick. The source has clearly denoted four main sections within the text: introduction, solution to knowledge gap, specific aims, and conclusion. The analysis in this study will follow this structure.

To verify the recommendations, I used samples of Specific Aims sections within successful NIH Division of Cancer Control and Population Sciences research grants. These samples were obtained from publicly accessible Cancer Epidemiology grant proposals submitted by research teams not affiliated with industry where the topics related to specific cancers. From these parameters emerged four proposals which were then selected for the project. The table in **Figure 1** presents metadata on the samples used. These samples were analyzed for similarity with Swick's recommendations. If

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Project Title	Lung Cancer in Never Smokers: Incidence, Risk Factors, and Molecular Characteristics in Asian American, Native Hawaiian and Pacific Islander Females	Symptom Progress and Adverse Health Outcomes in Adult Childhood Cancer Survivors	Risk Factors for Breast Cancer Subtypes in Racial/Ethnic Minorities	Genetic and Environmental Etiology of Familial Small Intestinal Carcinoid Cancer
Authors	Scarlett L. Gomez, M.P.H., Ph.D. and Iona Cheng, Ph.D., M.P.H.	I-Chan Huang, Ph.D. and Kevin Krull, Ph.D.	Esther M. John, Ph.D., M.S.P.H.	Deborah Neklason, Ph.D.
Affiliation	Cancer Prevention Institute of California	St. Jude Children's Research Hospital	Cancer Prevention Institute of California	University of Utah
Length of Proposal (pages)	49	29	27	28
Length of Specific Aims Section (pages)	2	2	2	2

Figure 1: NIH Research Grant Proposal Samples Utilized in the Study

two or more samples confirmed Swick's recommendations, the recommendation was approved. If more than half recommendations were verified, the text was deemed verified.

3. Results

3.1. Introduction

Based on the guidelines presented within Swick's article, the introductory paragraph must grab the attention of the reviewers and present the following information: a hook, a presentation on what is known in the field on that topic, an exposition of what is not understood in the field, and an emphasis on why this gap in knowledge needs to be filled [5]. The first sentence should be loaded with a conveyal of the urgency to solve a research question and the reason for it as well. These must be loaded into the very first sentence of the specific aims [5]. To maintain a general approachability to the texts, it is important to explain what is known in the field in a limited amount of sentences, and it is suggested that this should be done within three to five sentences [5].

The samples mostly reflect the recommendations, with most deviations occurring with the amount of context provided and where the samples convey urgency. All samples mention mortality in some way which conveys urgency by its seriousness in consequence. It is arguably difficult to find a situation more serious or urgent than death. The samples

also either claim that their research's broader goal is to improve understanding or patient care.

Looking at the sample by Gomez and Cheng, we see that Swick's recommendations are generally validated. Gomez and Cheng clearly note an urgency in their opening sentence by noting that "Lung cancer is the leading cause of cancer deaths among Asian Americans, Native Hawaiians and Pacific Islanders (AANHPI)," which once again presents a dire situation merely in the mentioning of death. The text also presents a brief conceptual overview and denotes the gaps in understanding by mentioning the "unknown[s]" and the "lack of information" that "constitutes a critical gap in knowledge" [1]. This connection between a lack of information and a deadly pattern then sets up the claim of urgency in "understanding and reducing the burden of disease in this heterogeneous population" [1]. The sentences between the introductory one and the claim of urgency provide additional context into the topic and span around seven sentences based on the model created by Swick, which do not follow the recommended two to five sentence span.

The proposal by Huang and Krull similarly reflects the recommendations. It also presents a sense of urgency in the introductory sentence with the mention of death. The introductory sentence also exposes the challenge that the researchers explore: the "advances in treatment and follow-up care" still leave childhood cancer survivors "vulnerable to late effects", including death [2]. A knowledge gap is presented by mentioning that "it is unclear to what extent symptom clusters affect long-term adverse health outcomes" [2]. The second paragraph of the section elaborates further on how previous studies into the topic were limited in scope due to their research method, thus creating a gap in understanding of how symptoms changed over time. The introductory paragraph presents various statistical information on the frequency of cancer related symptoms which would be considered excessive by Swick's recommendations to include only the necessary contextual details.

The proposal by John has a similar following of recommendations as it presents in the first sentence the urgent topic of mortality from breast cancer (BC), but it also presents the knowledge gap in saying that it "remains unsolved whether BC risk factors differ by race/ethnicity" [3]. Similar to the proposal by Huang and Krull, this proposal extensively presents contextual information spanning eight sentences with detailed explanations on definitions of body mass index, incidence rate percentages of BC, results from other analyses, among other information [3]. Another presentation of urgency, this time more explicit, appears at the end of the introductory paragraph enunciating that "there is an urgent, yet unmet need to learn about risk factors for BC subtypes in racial/ethnic minority populations" [3]. The phrase "unmet need" here not only conveys an urgency in addressing risk factors amongst populations, but it also reveals that the topic is yet to be investigated [3]. Although this detail is presented in a location different from what Swick recommends, it is nonetheless present in the Specific Aims section.

Looking at Neklason's Specific Aims, we see in the open-

ing sentence the concern for an increasing incidence rate of small intestinal carcinoid cancers (SICC). There are three or four sentences, of contextual information in this paragraph, excluding the information on unique resources and a call to understand these risk factors. Although there is slight statistical information presented (ie "standardized incidence ratio of 28 in siblings and 10 in parents," "5-year survival is less than 50%" [4]), the information is crucial to highlighting the urgency of the problem and a general understanding of where the research topic stands today. Furthermore, the statistical information does not compose the majority of the contextual information presented. The problem in this subsection is generally defined as the increasing "understanding these risk factors" that have contributed to the increasing incidence of SICC [4]. Gaps in knowledge are highlighted by phrases like "not explained" [4]. Swick's recommendations are thus reflected most in Neklason's Specific Aims.

3.2. Solution to Gap in Knowledge

According to Swick, the second paragraph or subsection within the Specific Aims section should propose a solution to the previously described gap in knowledge that urgently needs to be filled [5]. To provide the research with a clear focus and set of goals, it is considered important to provide in this section a clear hypothesis, an explanation of how the hypothesis was established, objectives for the project, a goal that is long-term and beyond the scope of the work done for the current grant, and a presentation of the researchers' qualifications for leading the project [5]. In justifying why the researchers are the most qualified to lead the project, it is acceptable to state the particular resources the researchers have access to or their previous experience or data [5].

This section shows the most deviations between Swick's suggestions and the sample proposals. The presence of the content recommended by Swick is dispersed through various paragraphs, often blurring the line between the distinct subsections that the source proposes. All these sources to an extent provide information on the solution to the problem with some samples being more explicit about this.

Swick's recommendations are adequately reflected within the proposal by Gomez and Cheng. There is no clear hypothesis presented in the proposals that would suggest the researchers' anticipated results from the study. Thus, there is also no hypothesis rationale. There is, however, a statement of the objective, denoted by the keyword "objective" [1]. The objective thoroughly describes what type of data the study will analyze and for what purpose, and reflects the gap in knowledge the text's earlier discussions focused on: the incidence of lung cancer and its epidemiology, stratified by ethnicities and smoking status. The long term goal is presented in the document as "reducing the burden of disease" in the AANHPI population [1]. This is the long term goal as this study only tasks itself with understanding the risk factors; it is subsequent research that will then have this knowledge to create active solutions for reducing the effect of risk factors. There is no mention of any qualifications of the researchers to show for why they are most capable of leading

this research study. However, this could be perhaps due to the researchers' association with the Cancer Prevention Institute of California that may set them up to have more resources towards cancer research than other institutes without a specialization in cancer.

Looking to Huang and Krull's proposals, we see greater deviation in the recommendations. First, the Specific Aims section is devoid of any hypothesis or anticipated result for the study. In the second and third paragraph of the section, the gap in knowledge (highlighted by the key words and phrases "unclear", "although", "no studies have investigated" [2]) is elaborated upon as a foundation for the explanation of why this particular research method is developed by describing the limitations of previous studies in identifying a change in symptoms over time. The proposed solution to the gap in knowledge – how symptoms change over time – is a study that analyzes cancer survivor data that spans multiple years.

The section also points out the "unique opportunity" that is present in the studies, resources, and participants that their hospital presents to them [2]. The section also presents an explanation as for why the researchers already have the tools and access to set them up for a thorough study. Highlighting the exclusive resources that these researchers have access to provides proof as to why these particular researchers are most qualified to lead a research study on these topics, and it matches what the recommendations by Swick.

While there is no explicitly denoted objective, it could be interpreted that the objective is to "examine data collected from survivors" [2].

The hypotheses in this document are also clear, but they do not provide an explanation for how they were formulated. The first hypothesis (1a) is arguably clear as it presents an anticipated causal association between the intensity of treatment and the number of and severity of symptoms. Based on what the aim is set to investigate (comparing type of treatment to a changing of symptoms over time), Hypothesis 1a is testable. Hypothesis 1b also presents a causal relationship between time and the occurrence of symptoms as well as the type of treatments, which fits with what one of the aims hopes to uncover. Similar pattern occurs with the last two hypotheses (2a and 2b) as they predict relations and comparisons, which both are testable with the second aim of the study.

There are also no longer term goals presented beyond the scope of this study.

John's proposal deviates in different ways in this subsection. John provides possible problems to previous studies ("small sample sizes", looking towards only one race or ethnicity in a study, and so forth [3]), which serve as rationale for why John decided to combine various studies on a cancer subtype in his study to make a comprehensive analysis on risk factors. The gaps in knowledge are presented further in this manner, and from there John presents his hypothesis about the similarity between risk factors across racial and ethnic groups. The hypothesis is signaled clearly by the phrase "We hypothesize that" [3]. There is no explana-

tion present, however, to back the rationale for the hypothesis. Details of the researcher's qualifications, long term goals, as well as an explicit statement of objectives are also absent.

Neklason's proposal follows a similar pattern. Within Neklason's Specific Aims, there also is no hypothesis or clear objective presented for the study. In the introductory paragraph, however, Neklason's claims that they "have the unique opportunity to use a one-of-a-kind resource to investigate environmental exposures AND inherited genetic risk factors" [4]. While this statement does not reveal what this "resource" is, it more broadly attempts to provide qualifications for why the researchers may be most capable of leading a study into this topic, which is what the Swick recommends. Long term goals are also not present in this section.

3.3. Specific Aims Declaration

After the research problem and proposed solution have been discussed, Swick recommends the specific aims be presented as a means to test the hypothesis. The aim itself should be active and concise, and there typically are around two to four aims [5]. Swick further adds that the independence of these aims is critical so that there are many safety nets to test the hypothesis in the case that one of them fails to assist in the testing of the hypothesis [5]. Furthermore, the aim should be followed by a brief elaboration and description of the experimental strategy and proposed outcome or impact of such a result towards the hypothesis. Where needed, sub-aims could be added to give an aim more depth.

The samples all largely reflect what Swick claims is necessary to have. They each contain two aims as Swick prescribes. All the samples contain active verbs within their explicitly stated aims, and the aims are all independent in nature. Variations in the aim stem from the quantity and extent of the description of the experimental strategy for these aims.

The aims subsection within Gomez and Cheng's proposal completely reflect the suggestions. The aims themselves seem independent too; one investigates "cancer incidence rates" while the other investigates risk factors. These two claims are independent as the knowledge of incidence rates does not overlap significantly into the risk factors that people may have. Risk factors are a micro investigation, whereas incidence rates analyze a population as a whole. The aims are presented with descriptions of the experimental strategy, discussing what will be done in the experiment to attain the aims: calculating incidence rates and conducting "a longitudinal analysis of lung cancer risk" [1]. The aims also detail the variables that will be investigated, providing a thorough description of what is to be examined and on what fronts the research could provide insight into. The aims and experimental strategy both contain active words like "identify," "characterize," "calculate," "compare," "examining," and "conduct" [1]. Not specific to any aim, the section also details what data will be obtained for this study and how it will be collected.

The aims within Huang and Krull's article similarly follow the guidelines. The two aims are active using the word

“investigate” to give action, and they also detail the variables that would be collected and analyzed as a part of the elaboration of the experimental strategy: symptom domains (ie. “sensation abnormality, motor/movement problems, cardiac symptoms”) and “prognostic value” [2]. The aims are also independent in that regard.

John’s proposal follows the guidelines to a smaller extent, with most deviation occurring from the lack of a description of the experimental strategy for each of the aims. There are two aims present, and each contains the active verb “assess” [3]. A reason for this deviation could be because an experimental approach was given for the hypothesis, so an explanation for each aim would be redundant. Additionally, both aims seek to assess certain factors, to which the experimental approach is the same, so a generalized experimental approach might as well be best for this proposal. Without knowing the particular experimental strategy for each of the aims, it cannot be definitively stated that the aims are independent; however, the difference in what the statistical analysis looks for can contribute to independence. For the purposes of this study, the aims here will be considered independent in this regard.

The aims within Neklason’s proposal reflect the recommendations well. They contain the action words “identify” and “model” and both explicitly elaborate on the type of data that will be analyzed and for what they will be analyzed for [4]. The aims in this document are also independent. One identifies genetic variants while the other creates risk profiles based on a slightly different set of data. The aims are very thorough in describing what information will be gained and how it will be gained and analyzed. There are descriptions as to what the researchers have already identified for this study, allowing researchers to understand where else this information could go to use. Elaborating on the types of details that will be gained allows a clear presentation of what other data could be obtained and synthesized, allowing readers to understand how other researchers could potentially utilize this research for future studies.

3.4. Conclusion

To conclude this section, Swick considers it fundamental to re-broaden the scope of the discussion away from the particular study back to the broader implications of the research project [5]. The overall impact and significance of the research must be discussed to leave the reviewers with another declaration of the importance of the project after receiving a more explicit elaboration on the project with the aims described.

As for the broader conclusion, all samples emphasize the broader implications of their research.

Gomez and Cheng present the implications in the sentence “This highly efficient study will have the unprecedented capability to provide the much-needed information on lung cancer risk among AANHPI never smokers, serving as a critical evidence base to inform screening, research, and public health priorities in this growing population” [1]. The sentence highlights the innovative nature of the study with the

words “unprecedented” and “serving as a critical evidence base,” but also draws a connection to other applications of the study beyond the field of research.

Huang and Krull reveal their broader impact in this paragraph: “This study will provide an important foundation toward improving quality and efficacy of medical interventions for childhood cancer survivors. Our results will help clinicians determine appropriate sentinel symptoms that may lead to early screening for adverse medical events (e.g., unexplained cardiac arrest), and promote early symptom interventions to reduce the likelihood of future morbidity and mortality” [2]. Here, the connection from research to patients and doctors emphasizes the useful applications of the study’s findings. By emphasizing the benefits patients can have, Huang and Krull make the purpose of their study less abstract, and allow the readers to see the proposal as a matter of directly helping patients.

In John’s proposal, the impact is highlighted in the last sentence of the section: “If differences in risk factors emerge across racial/ethnic groups, such findings will identify areas for more in-depth scientific investigation, as well as opportunities for tailored primary prevention strategies that are directly relevant for specific racial/ethnic groups” [3]. In this sentence, John highlights how future research could be prompted, thus suggesting that his research is a necessary stepping stone for the field.

Lastly, Neklason emphasizes this aim in the second to last paragraph of this section: “This body of work is important to identify genetic and environmental risk factors for SICC and define individuals who would benefit from screening due to their genetic risk or environmental exposure” [4]. Similar to the other aforementioned texts, this sentence connects the proposed research to the patients that could benefit from its findings, and in this way allows the study to become less abstract in its benefit.

3.5. Summary of Recommendations & Usage in Successful Proposals

Refer to the **Figure 2** for a table summarizing the findings in this study.

4. Discussion

The samples deviated greatly from the recommendations in the amount of context they provided, and thus the recommendation relating to the amount of content is invalidated. The recommendations cannot be confidently validated because only two samples reflected the recommendations are the inclusion of the hypothesis, objectives, and a presentation of researcher qualifications. Although not listed as a full invalidation of a recommendation, the location for some recommendations within the samples was not consistent, and some elements were found in other subsections. Regardless of these organizational variations, the samples might have still contained the corresponding content, thus suggesting that organizational details are not crucial to the success of the section. Otherwise, all other recommendations by Swick are therefore verified.

Specific Aims in NIH Grant Proposals

An "X" symbol denotes the recommendation as being reflected in the sample. An absence of a symbol denotes the recommendation not being reflected in the sample. An "O" symbol denotes the recommendation being partially reflected in the sample. The recommendations are grouped and color-coded by the subsection within the Specific Aims section they correspond to.

	Gomez and Cheng	Huang and Krull	John	Neklason
Hook	X	X	X	X
Gap in Knowledge	X	X	X	X
Urgency	X	X	X	X
Minimal Context	O			X
Hypothesis		X	X	
Objectives	X	X		
Elaboration on Proposed Research Method	O	X	X	X
Researcher Qualifications		X		O
Two to Four Aims	X	X	X	X
Independence of Aims	X	X	X	X
Description of Experimental Strategy for Aim	X	O		X
Active	X	X	X	X
Overall Impact & Broader Implications	X	X	X	X

Figure 2: Summary of Findings, comparing the recommendations to the samples of successful proposals.

A possible explanation for why some samples deviated from each other in the recommendations they reflected may be that the Specific Aims section is a holistic document that is not solely dependent on any of the elements the samples had variations of.

An important limitation to note for this study is accessibility to publicly accessible research grant proposals not just to the NIH, but to all grant committees. The limited access to the documents could have hindered the true presentation of successful research grants. Additionally, rejected NIH research grants were not accessible for this study, and future research could be done to analyze what components are shared and absent between successful and failed grant proposals.

5. Conclusion

The guide by Swick is an excellent starting tool for researchers to utilize, and it outlines the various elements that have been utilized within the successful grant proposals. Recommendations on the inclusion of a hypothesis, objective, and researcher qualifications should be recognized as not crucial to the success of the grant proposal. If researchers are to utilize this resource for their grant proposal, they can produce higher success rates in grants, thus saving time and resources.

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About the Author Masha Bondarenko is an engineering undergraduate at the University of California, Berkeley where she hopes to lead her own research project in the coming years.