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Research During Fellowship*

Ten Commandments

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Key words: fellowship and scholarship; mentors; research

Abbreviation: ReSCU = Respiratory Special Care Unit

Doing research is a critical component of an academic training experience for a fellow for at least four reasons, as follows: (1) the experience allows fellows to assess their interest in research and in its conduct as a core component of the career to follow; (2) the experience of doing research provides fellows with the opportunity for mentorship; (3) the research may jumpstart fellows' academic careers by initiating an area of content expertise, and allowing the beginning of a stream of inquiries and publications in that area¹; and (4) the activities of doing research (*eg*, formulating hypotheses, presenting the research in various forums, writing grants, and submitting abstracts and [hopefully] manuscripts) offer the fellow practice in honing these skills in a mentored setting. Because doing good research is enhanced by experience, it behooves the fellow to harvest as many lessons (both do's and don'ts) from the training as possible. In this context, this article was written in the hope of both crystallizing and sharing lessons from a pulmonary/critical care fellow's research experience. Though eager to avoid the

appearance of hubris in formulating these lessons as "Ten Commandments," we submit that framing this experience as commandments may lend the appropriate air of admonition to allow the reader to approach the experience as carefully as possible.

Having become fascinated by the concepts of homeostasis and physiologic regulation early in training, the first author (hereafter referred to in the first person) had wanted to study heart rate variability of critically ill patients well before beginning my training in the United States. However, timing, studies, immigration, and program changes all precluded my starting such an inquiry. Thus, by the time of my arrival at the fellowship, the combination of pent-up desire and the opportunity to undertake any area of interest propelled my studying the variability of heart rate and temperature in patients in the Respiratory Special Care Unit (ReSCU) at the Cleveland Clinic.

The specific hypothesis that framed my study was that the analysis of temperature and heart rate variability, as a marker of autonomic integrity, may predict weaning in patients undergoing prolonged mechanical ventilation. The study involved patients receiving prolonged mechanical ventilation who had admitted to the ReSCU. I measured heart rate variability on hospital admission and discharge, and the temperature complexity curve throughout the patient's stay in the ReSCU. Notably, my passion for this line of research led me to proceed knowing full well that there was no prior experience among the pulmonary/critical care faculty (and, in fact, in the whole organization) in measuring or analyzing such data and that the devices for recording variability were not available at the study outset. Thus, it was apparent to me that conducting this research would require substantial personal learning, networking with international experts (*eg*, in Spain and Finland), and the assembly and testing of requisite equipment and software.

In the end, I undertook this line of study, which has allowed me to collect my thoughts in this article. Though my work was undertaken as a fellow in

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pulmonary/critical care medicine, I believe the lessons are generalizable. Like the Ten Commandments, my lessons seem prescriptive; failure to heed them may incur the consequences of disappointment and much work expended without “tangible” output. At the same time, we wish to emphasize the following two points: (1) doing research offers the opportunity for huge learning, irrespective of whether the research generates scientific insights or traditional academic output (*ie*, abstracts, papers); and (2) heeding these commandments offers the reader an opportunity to make a fully informed decision regarding the substantial research effort to follow. Our proposed Ten Commandments follow.

COMMANDMENT 1: IF IT IS NOT THERE, YOU CAN'T USE IT

As part of the initial assessment about proceeding with the research effort, you need to conduct an “environmental scan” of your department and of its intellectual and facilities resources.² To be sure, if, at the beginning of the research study, you lack the needed equipment and infrastructure (including the intellectual infrastructure around you), then obtaining these required elements can be very challenging and time consuming. Much of research depends on networking and informal discussions with other interested parties; hence, availability is essential.

Take-Home Lesson

As you begin your research, do this “environmental scan” about the requisite conditions to successfully and satisfyingly undertake the research. Specifically, are colleagues or mentors who are experienced in the field available to you locally, at least enough to offer meaningful content guidance? Is the needed equipment available or will you be expected to obtain and learn to use it by yourself?

COMMANDMENT 2: EVERYTHING TAKES LONGER THAN YOU THINK!

There is a seemingly universal tendency to underestimate the amount of time and energy needed to conduct research. Specifically, to begin a research study, you will need to achieve several goals before you start recruiting patients. These goals start with developing the protocol, obtaining permissions and funding, acquiring equipment, and learning the necessary techniques. Depending on local institutional features, the times required to achieve each step may vary. Several realities conspire to extend the preparatory time for research, even before the first patient

is recruited, as follows: (1) the fellow's available research time is limited and may be interspersed with clinical responsibilities; (2) many deadlines are nonnegotiable (*eg*, submission dates to the institutional review board) and may be missed; and (3) some of the preparatory steps are sequential rather than synchronous. These preparatory steps took approximately 12 months, and by the time I began recruiting I had consumed half of my allotted fellowship research time.

Take-Home Lesson

When planning your project, consider the time available in your fellowship and recognize that, even if you have everything set, it will take several times longer (I estimate threefold longer) to achieve your goal.

COMMANDMENT 3: MURPHY'S LAW APPLIES TO EQUIPMENT: IF IT CAN BREAK, IT WILL BREAK

While the goal in a well-conducted study is to troubleshoot all equipment and to “debug” all assays by repeated trials in order to streamline the study and minimize the likelihood of interruption, Murphy's law of equipment rules; unanticipated and unwelcome interruption is common, perhaps universal. In my research, the recruitment of the first patient was so smooth that I was lulled into a sense of seamless flow (which was both intoxicating with excitement and belied the later realities of equipment failures). In reality, in no fewer than 20% of the study subjects' recruitment and assessment was there an unanticipated and time-consuming diversion, for instance, to fix an instrument or debug a process. For example, after I finished the complete protocol with a single patient, the recordings demonstrated that his skin temperature was approximately 79°C for most of the study. The temperature probe, I learned, was not waterproof, and the measurements were in error because of water leakage, an insight that invalidated 15 days of recordings on this patient and required extensive recalibration.

Take-Home Lesson

Having spare equipment and frequently assessing all the components is essential. Expect delays related to equipment malfunction, and plan for them in your timeline (even if you feel lulled into security by the compulsiveness of your preparation).

COMMANDMENT 4: THE MORE DATA YOU GENERATE, THE LONGER IT TAKES TO ANALYZE IT

When designing your research protocol, pay close attention to the amount of data to be gathered and

analyzed, as these will importantly affect the time needed to collect, analyze, and report the data.² I had carefully considered the time needed to obtain the data but had failed to fully understand the complexity of the analysis. For example, the temperature monitors, once attached to the patient, could record data for 18 days. I had decided to obtain temperature recordings every minute (instead of every 10 min as in prior reports) under the premise that the data could always be pared down. While the argument seems appealing, the consequent volume of data was daunting. Specifically, the mean subject length of stay was 14 days (range, 3 to 51 days) such that, at the time of the writing of this article, I had approximately 290,000 temperature readings and 15,000 heart beats recorded on 10 patients! Although this exhaustive collection arguably proved to be useful and perhaps improved my ability to draw conclusions, the volume of data proved mentally distracting and physically hurtful in the carpal tunnel syndrome that developed during incessant key-boarding.

Take-Home Lesson

Lack of data hurts, but excess data can overwhelm your mental and physical capacities. Be judicious in setting the data goals!

COMMANDMENT 5: EVERYONE NEEDS HELP; IT TAKES A VILLAGE TO DO RESEARCH

It is critical to have colleagues and mentors at hand who have interest and experience in the line of study and, ideally, the analytic techniques being used. Furthermore, as in all team building, the roles, goals, and responsibilities of all research team members need to be chartered at the outset, so that all parties understand the magnitude and quality of their respective contributions to the research. This chartering allows each member of the team to be fully engaged and to allot requisite time to the study at times when their input is needed.^{2,3}

Take-Home Lesson

Establishing a network involving your mentor, colleagues, statisticians, and ancillary support individuals is critical to sustain the research effort. The fellow should create interest in the research, prompt the discussion about roles, goals, and responsibilities, and serve as the “glue” that maintains momentum in the research, all of which is best accomplished within a local community.

COMMANDMENT 6: NO RECRUITMENT, NO STUDY

All well-planned intervention studies include an estimation of the treatment effect and a related power calculation, which generates a suggested number of study subjects in each study arm.⁴ That said, estimates of “recruitable” subjects are often optimistic and exceed reality. Alternately, patterns that have been used to predict recruitment may change, causing actual recruitment to fall behind projections. For example, in the current research in which study goals were based on longstanding patterns of admission to the ReSCU, yearly admissions had consistently numbered 50 to 60 a year, until I started this study. Based on prior patterns, I had expected to recruit approximately 20 patients in 6 months. It turns out that during the first 6 months for the study, two of the available rooms were unexpectedly closed for construction. Hence, only 20 patients were admitted to the ReSCU over the course of my research, and only 11 subjects were recruited.

Take-Home Lesson

You need to recruit patients in a relatively short period of time such that you can obtain data, analyze it, and then write and submit an article before the fellowship is over. Halving recruitment projections may be prudent.

COMMANDMENT 7: INTEREST ALWAYS WANES

As a general rule, the fellow’s enthusiasm for the research at the outset should be very high, to assure that it remains high as the work unfolds (because interest always wanes, at least somewhat). As passionate as I was to undertake the research (which caused me to pursue it even over the admonitions of some mentors who pointed out some of the commandments about which I write here), my enthusiasm was challenged by the adversities I faced, for example, in understanding the concepts, procuring equipment, assuring that equipment functioned, and accruing patients. Waning interest is more likely when commandment 5 (“It takes a village to do research”) is violated; regular get-togethers with others invested in the research outcomes will tend to preserve or reinforce interest, including the importance of achieving milestones (*eg*, the need to write an abstract, present a talk, or prepare a manuscript [see commandment 9 below]). Lack of these encounters (*ie*, because local colleagues are not available) makes the waning of interest more likely.

Take-Home Lesson

Interest in the topic will gradually reduce as time goes by, especially when you are working solo.

COMMANDMENT 8: YOU CAN ALWAYS SAY “NO”

Though not the case in the research project I am discussing here (where my own passion to do the research drove the work rather than any prodding from a faculty member), fellows are often invited to participate in research by faculty engaged in the research. Because ambitious fellows are often keen to amass publications and faculty are often keen to engage fellows in their research, the stage is set for a coercive interaction (*ie*, the fellow may feel obliged to participate, even if she/he is already overextended with other clinical and/or academic obligations). On the axiom that you should generally finish what you start by the time you leave the program, beware of overextension! It is better to say “no” and complete all the work to which you are committed than it is to say “yes” and not finish the work. At a minimum, do not respond to invitations immediately. A response to a faculty member’s invitation to collaborate such as “Sounds very interesting, I’d like to think about it for a short time and I will get back to you” will decompress the issue for the moment, allow you to think carefully about your level of enthusiasm (because commandment 7 rules), and perhaps allow you to seek the guidance of another faculty mentor in saying “no.”

Take-Home Lesson

While it may be hard to say “no,” it is generally better than saying “I could not deliver.” As a venerated mentor once said (N. S. Hill, MD; personal communication; October 2008) “If you don’t use certain ‘two letter words’ enough (*ie*, “no”), you’ll end up using certain ‘four-letter words’ a lot more.”

COMMANDMENT 9: YOU NEED DEADLINES

You will need deadlines to assure steady progress. Schedule regular meetings in order to coordinate, troubleshoot, and review progress with your mentor and other members of the team. In my research, several milestones were important in keeping me on track, especially because local colleagues and the stimulus of regular conversations about the research were not available to me (see commandment 5). A “research in progress” report to the department on the status of the research helpfully forced me to take stock of my progress and identify research needs and questions going forward.

Take-Home Lesson

Deadlines maintain interest, help you identify pitfalls, and may prompt other ideas and projects.

COMMANDMENT 10: TURN EVERY EFFORT INTO A PAGE

In the ideal (and perhaps as a stretch goal), every investigative effort would generate a report of some sort, whether an abstract, manuscript, or oral presentation at a national meeting. Furthermore, the literature review so necessary to develop mastery of a content area can, in many instances, become the basis for a review article. In keeping with this commandment, while reviewing the literature, designing new techniques, or analyzing the data, maintaining careful notations will later help as the backbone for your publication, without repeating efforts (*ie*, rereading previously reviewed data).

Take-Home Lesson

Look for every opportunity to turn your work into a publication.⁵

CONCLUSION

In summary, my own experience studying temperature and heart rate variability in patients weaning from mechanical ventilation was bittersweet, at once disappointing in its failure to yield systematic understanding of the issue despite the substantial effort expended, and, on the other hand, enriching in its lessons and in its demonstration of my solitary ability to master complex material, to develop measurement systems, and to reflect on the strengths, weaknesses, and opportunities of this research experience. Most importantly, I learned an immense amount about initiative and improvisation, and about how to conduct (and, importantly, how not to conduct) research. My hope is that this advice will help others avert some of the pitfalls of my experience while supporting the joy of understanding that a research experience can bring.

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