Methodology Matters

Numbers etiquette in reports of pharmacy education scholarship

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Abstract

Clear communication is of vital importance when reporting the results of any scholarly efforts. Despite current guidance on the appropriate reporting of study designs and research methods, there is relatively little to guide authors when reporting numbers in quantitative results. While researchers usually focus on being as precise as possible in both measurement and reporting, there are important issues to consider given the limitations exhibited by most people when reading and interpreting numbers. The use of excessive decimal places can result in suggesting higher levels of precision than are actually available and even result in confusion or misinterpretation by readers. This article reviews aspects of quantitative reporting and provides recommendations for best practices when reporting quantitative results of pharmacy educational scholarship. After reading this article, readers should be able to report quantitative findings with an appropriate level of precision given the particular measurement methods used in their investigations.

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Our situation

Practically speaking, people's comfort with numbers is a continuum. Some people have a greater affinity for and are more confident with a multitude of numbers than others. Naturally, we are all more versed and confident with data and numbers from our own investigations than most readers would be. As we report our scholarly efforts in pharmacy education, we need to be mindful of future readers.

In our roles as a statistician (S.E.H.) and an educational psychometrician (M.J.P.), we both frequently work with reports from projects that include numbers. One key aspect of any sort of quantitative analysis is clear and appropriate reporting of results, whether in text, tables, or graphs. Investigators have an imperative to be accurate with reporting, without inadvertently conveying false confidence

in levels of precision. The potential for misuses and abuses when reporting numbers is an important concern in scholarly reporting. In our collective experience as peer reviewers, we frequently encounter a common theme of misreporting quantitative results. We offer two perspectives that converge in our guidance with etiquette in reporting numbers.

Methodological literature review

Several guidelines exist to aid in the optimal reporting of various research methods and study designs (www.equator-network.org). Unfortunately, the same is not necessarily true when it comes to specific elements within a report, namely reporting numerical results. Cole recently noted, "Surprisingly, few guidelines on the subject exist."[1] Due in part to this lack of guidance, reporting summary statistics often have too many, or much less often have too few decimal places, which can adversely affect the ability of readers to understand the results and sometimes even cause confusion.

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An educational psychometrics perspective

Measurement of educational and psychological abilities has a history entwined with physical measurement, which was reviewed briefly in a previous Methodology Matters article.[2] Physical, three-dimensional measurements have an accuracy and precision of the specific instrument being used (e.g., ruler for height, thermometer for temperature, and sphygmomanometer for blood pressure). The same holds true for educational measurement except that the level of precision is far less certain. While a Class III prescription balance can weigh ingredients to three decimal places, it is extremely rare for educational test measurements to have anywhere near this level of precision.

Whenever we measure with a ruler, there is always error in that measurement. Our precision in those measurements depend on that ruler's units and whether it is in inches only, centimeters only, or includes millimeter graduations. We cannot add more precision than our instruments allow. Measuring knowledge, skills, and abilities is no different. Reports with many superfluous decimal places (e.g., mean test score of 87.36498) suggest a level of precision that simply does not exist. Unfortunately, some readers may interpret that apparent precision with increased confidence in the validity of those findings. In reality, authors probably have no intent to mislead when reporting seemingly high levels of precision by including many decimal places. Some might argue this is an artifact of the science training that many of us received prior to becoming pharmacy educators. When *reporting* results, the level of precision used must be justified by the measurement method(s) employed in the study. Paying attention to variability in the measurement approach (e.g., standard error of measurement or estimate) can help guide our reporting. A conceptual example using standard error of the measurement (SEM) is provided later in the Recommendations and Applications section.

A statistical perspective

Numeracy (or quantitative literacy) and the closely related concept of quantitative reasoning[3] are also important concepts to consider when reporting quantitative results. Math skills and statistical understanding among physicians, medical students, pharmacists, pharmacy residents, and pharmacy students has been shown to be low.[4–9] Somewhat surprisingly, physicians, nurses, and even pharmacists have documented difficulty with even basic dose calculations.[10–14] Unfortunately, assuming that health professionals have high quantitative skills and are "good" with numbers may not be a safe assumption.

People generally have difficulty interpreting more than two digits.[15] For example, a mean test score of 87.36498 would be difficult to grasp by even the most quantitatively astute reader. A reported mean score of 87 should, however, be readily understandable and is better than even 87.0 (though has a similar meaning). Although the additional decimal places may technically carry more information (setting aside for the moment whether this level of precision is even justified), the decimal places most likely do not change the meaning that readers may glean from the reported mean score (i.e., the mean is about 87). If anything the use of many decimal places may actually interfere with a reader's ability to understand, interpret, and remember the results being presented.[16] It is important to keep clarity in mind from a reporting standpoint since we must be careful to avoid causing any confusion when we report our findings. From a more technical standpoint, accuracy beyond two decimal places is rarely justifiable statistically, given that sample sizes in the tens of thousands would be necessary.[15]

Our recommendations and their applications

When reporting numbers, less is often more. As the guidelines on Statistical Analysis and Methods in the Published Literature (SAMPL) note, "Report numbers … with an appropriate degree of precision. For ease of comprehension and simplicity, round to a reasonable extent."[17] A difficulty with the SAMPL guidelines is that determining what constitutes an "appropriate degree of precision" or "reasonable" rounding is not always straightforward. The following recommendations provide further guidance on the reporting of quantitative results. These recommendations are not ours alone but have been developed after reviewing those from other sources and experts. For further reporting guidance on issues not addressed here, follow the most recent version (the 10th edition as of this article's writing) of the *AMA Manual of Style*.[18]

Many of the recommendations are based on significant figures (or significant digits). This topic is commonly included in many chemistry courses and forms a core topic in pharmaceutical calculations courses. As defined in *Remington: The Science and Practice of Pharmacy*, a significant Figure is a digit that has "practical meaning."[19] There are various rules for determining when a digit is significant, such as those discussed in the pharmaceutical calculations textbook by Ansel and Stoklosa.[20]

Two general rules-of-thumb support all of the following recommendations. First, be parsimonious. When reporting numbers, be as simple and frugal as possible. Do this especially in numbers-intensive tables where decimals can make the entire table more difficult to grasp quickly; rounding can be a very strong advantage to improve this type of reporting.[16] As Wainer states, rather forcefully, "[r]ound—a lot!"[15] The rounding rules provided in the *AMA Manual of Style*[18] are fairly straightforward and easy to implement. Second, be consistent in reporting throughout your manuscript. Use these recommendations as guidelines, and justify yourself if your report deviates from these recommendations. The following recommendations are summarized in Table 1. Additional resources providing more in-depth discussions and guidance on presenting