D29 Error and Uncertainty in Toxicology and Drug Analysis — Terminology Matters

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After attending this presentation, attendees will understand the key differences in the terms "error" and "uncertainty" as applied in forensic science. The emphasis will be on quantitative methods used in forensic toxicology and seized drug analysis, but the concepts are generalizable to any quantitative measurement.

This presentation will impact the forensic science community by clarifying the definitions and proper use of these two terms ("error" and "uncertainty") which are used to describe the utility and reliability of quantitative forensic data.

It is common for the term "error" to be used interchangeably with "uncertainty." For informal conversation this is harmless; in forensic science this usage is misleading and potentially dangerous. The two terms are not synonymous and describe two fundamentally different properties associated with any quantitative measurement. While neither error nor uncertainty can be eliminated from any measurement process, it is possible to provide reasonable and defensible estimates of both quantities. Error is related to accuracy (how close is a given value to a true value?) while uncertainty is related to precision (how reproducible is a given result?). An estimate of uncertainty does not imply doubt or a poor measurement process. Rather, an uncertainty estimate improves the utility and reliability of any measurement. It is critical that forensic practitioners use these terms properly and convey the differences between these two words to stakeholders in judicial proceedings. This presentation will clarify the terminology and offer suggestions for explaining and presenting the differences to law enforcement and triers-of-fact. The emphasis will be on quantitative measurements obtained in forensic chemistry, but the concepts are generalizable to any quantitative measurement.

One of the challenges in the forensic context is defining what measurements are quantitative. This presentation will touch on this issue. For example, with searchable databases, a quantity is produced that expresses the closeness of agreement between a questioned and known exhibit. Thoughts to consider for such metrics will be introduced.

"Error" in a quantitative measurement refers to the difference between the reported measured value and the true value.[1-4] Given that the true value of any measurement is inherently unknowable, error is estimated using reference materials. Ideally, error values are obtained from a source such as the National Institute of Standards and Technology (NIST); examples are certified weights and standard reference materials such as ethanol in water. Uncertainty is defined as the range in which the true value is expected to lie. Uncertainty is reported along with a probability, usually stated as a confidence level. Both of these concepts will be defined and clarified using examples from seized drug analysis (reporting the weight of an exhibit) and forensic toxicology (blood alcohol analysis and postmortem drug concentration levels). Suggestions will be provided to illustrate how these concepts can be conveyed to judges and juries using everyday examples.

References:

1. Standard practices for method validation in forensic toxicology. *Scientific Working Group for Forensic Toxicology*; 2012;1-49.
2. Rozet E, Marini RD, Ziemons E, Dewe W, Rudaz S, Boulanger B, et al. Total error and uncertainty: Friends or foes? *Trac-Trends in Analytical Chemistry*. (Review). 2011 May;30(5):797-806.
3. Wallace J. Proficiency Testing as a Basis for Estimating Uncertainty of Measurement: Application to Forensic Alcohol and Toxicology Quantitations. *Journal of Forensic Sciences*. (Article). 2010 May;55(3):767-73.
4. JCGM. JCGM 100-2008: Evaluation of measurement data (GUM 1995 with minor corrections). *JCGM: Joint Committee for Guides in Metrology*; 2008 (updated 2008 2008; cited); Available from: http://www.iso.org/sites/JCGM/GUM/JCGM100/C045315e-html/C045315e.html?csnumber=50461.

Error, Uncertainty, Metrology