E18 The Design and Analysis of Calibration Experiments and the Reporting of Prediction Errors

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After attending this presentation, attendees gain an appreciation of the design and analysis of calibration experiments and how to construct an appropriate prediction interval of the result.

This presentation will impact the forensic science community by serving as an introduction to the importance of expressing not just a number, but an interval to explain the uncertainty in the experimental work and setting appropriately derived quality standards rather than choosing an arbitrary percentage agreement.

The design of calibration experiments is critical in deriving an estimate of the prediction error in reporting a drug analysis result. The reporting of only a single number gives the impression that the result has a negligible error when in fact the error is dependent on the design of the calibration experiment and the number of predictions to be made from the calibration curve. A high R-squared from the regression of the calibration curve is often misinterpreted as showing linearity and a correct model though neither is correct. Neither does a high R-squared imply that the regression model will be an accurate predictor. It is often forgotten that randomization is the basis for many statistical tests and this is also true with the design of a calibration experiment. Failure to randomize will confound instrument drift and other problems that may arise in the analysis of samples limiting the conclusions that can be drawn from the experiment. An analysis of the residuals is important since this can highlight problems such as instrument drift and outlying and influential points. Usually the instrument software will allow the calculation of the calibration curve and then use that information to print out the associated values from the samples. One should resist this since just because the software lets you do it, doesn't mean that is should be done. A thorough analysis of the regression equation should always be done and this means using appropriate statistical software and evaluating coefficients from a statistical standpoint and examining various residual plots. The calibration experiment is a model and thus an appropriate statistical analysis should be done to verify the model. Furthermore, since this experiment will be repeated at regular intervals, a control chart of the results should be produced and updated after every run and this will provide further insights into the quality of the work and the predictions.

Predicting the appropriate result is more complicated than doing a simple linear regression and allowing the software to report a number. The prediction error on the result depends upon the number of standards in the calibration curve and the number of samples being tested. Running samples in duplicate may or may not provide additional information since it depends upon how the samples were prepared in the first place. Splitting the sample into two gives the error of the machine, not the error on the sample. A complete analysis must have a well delineated standard operating procedure that clearly explains every step of sample preparation and analysis. The standard operating procedure should also define the mathematical and statistical model being tested with the appropriately validated statistical software to be used. Some analyzed examples will be presented using alcohol and ecstasy (MDMA) to show both what to do and what not to do.

Calibration, Prediction Error, Experimental Design

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