B86 Quantifying Uncertainty in Estimations of the Total Weight of Drugs in Groups of Complex Matrices Using the Welch-Satterthwaite Equation

Ivo Alberink, PhD, Netherlands Forensic Institute, Laan Van Ypenburg 6, The Hague, Zuid-Holland 2497 GB, NETHERLANDS; Annette Sprong, BSc, Netherlands Forensic Institute, Laan Van Ypenburg 6, The Hague, NETHERLANDS; Annabel Bolck, PhD, Laan van Ypenburg 6, Den Haag 2497 GB, NETHERLANDS; and Peter Vergeer, PhD, Netherlands Forensic Institute, Laan Van Ypenburg 6, The Hague, NETHERLANDS*

After attending this presentation, attendees will better understand the use and robustness of a new statistical method to quantify estimations of total drug weight in groups of items, based on the Welch-Satterthwaite equation.

This presentation will impact the forensic science community by introducing a new method to quantify estimations of total drug weight in groups of complex matrices.

In a recent case at the drugs department of the Netherlands Forensic Institute (NFI), materials were received from the Schiphol national airport consisting of 43 T-shirts, boxer shorts, shorts and blouses; 12 socks; 8 vests and short trousers; 5 pieces of denim clothing; and 2 towels. Based on a color test, and verified by Gas Chromatography/Mass Spectrometry (GC/MS) analysis, the items were impregnated with cocaine. This type of casework is encountered often and the crucial question is: what is the total drug weight in the combined items? In order to answer this question, standard laboratory procedures have been developed. First, the total weight of each item is determined, then repeated concentration measurements are performed on some or all of the items (in this particular case, for example, not all items from groups 1 and 2 were sampled). The concentrations are measured using Gas Chromatography/Flame Ionization Detector (GC/FID) on samples taken from different locations on the items.

In the literature, guidelines exist on the expression of uncertainty in analytical measurements; additionally, the International Organization for Standardization (ISO) 17025 requires that forensic laboratories determine uncertainty on their measurements. The issue of how to sample from consignments of drugs, and how large samples should be in order to obtain required results, has been widely discussed. Frequentist and Bayesian methods have been described in cases in which no measurement uncertainty is attached; however, these studies do not address the question of how to deal with a situation in which considerable uncertainty is attached, which may differ for each item.

The question as to the total amount of drug weight, and the precision of its estimation, in the combined items may get complicated, and statistical methodology to handle this has been described.[1] The methodology is based on the following assumptions: (1) within each of the groups, the relative standard deviation on repeated measurements is the same; (2) the measurements are unbiased estimators of the real concentrations of drugs in the items, and repeated measurements on the same item (at different locations) are normally distributed; and, (3) when sampling takes place in one or more of the groups, the real concentrations of drugs in the items of the group are normally distributed.

It may happen that, for example, the assumption of a constant relative standard deviation is violated, or that normality of the measurements is untenable (e.g., for data with point masses at zero or if certain items in a group have a very high standard deviation). In cases such as these, it makes sense to use a model in which the relative standard deviation may be different for each item. A method is described for dealing with this type of situation

based on the Welch-Satterthwaite equation, both for cases in which all items are sampled and cases in which this is not so. In this set-up, the assumption of constant relative standard deviations is not necessary.

In this presentation, case examples will be presented in which the method is applied, both for the situation in which all items are sampled and the situation in which this is not the case. Furthermore, results of simulation studies will be shown that study the effect if the data are not normally distributed but uniformly or if a substantial amount of them contain zeros (measurements are on locations containing no drugs at all). The simulation studies suggest that both the method described in this presentation and the methods described by Alberink et. al yield reliable results, including if data have point masses at zero or a large standard deviation.[1] Coverage of 95% intervals is always close to 95%. If the assumption of common relative standard deviations clearly does not apply, it is nonetheless advised that the method based on the Welch-Satterthwaite equation be used.

Reference(s):

1. Alberink I., Sprong A., Bolck A., Curran J.M. Quantifying Uncertainty in Estimations of the Total Weight of Drugs in Groups of Complex Matrices. *J. Forensic Sci.* 59 (6) (2014) 1614-21.

Drug Weight Estimation, Measurement Uncertainty, Welch-Satterthwaite Equation