Equations For Solving Problems

1. Widmark's Equation

$$N = \frac{Wr(C_t + \beta t)}{0.82(fl.oz.\ EtOH/drink)}$$

where:
- N = number of drinks
- W = body weight in ounces
- r = Widmark's ρ (rho) (L/Kg)
- C_t = BAC(Kg/L) at time t and approximated from BrAC measurement
- β = elimination rate (Kg/L/hr)
- t = time in hours from first drink
- 0.82 = density of ethanol (oz./fl.oz.)

2. Widmark's Method For Computing the Uncertainty in Widmark's Equation

$$1\sigma = \sqrt{0.015625\,N^2 + 0.050176\left[N - \frac{0.68\,C_t\,W}{0.82\left(fl.oz./\,drink\right)}\right]^2} \quad \text{for men}$$

$$1\sigma = \sqrt{0.01\,N^2 + 0.021904\left[N - \frac{0.55\,C_t\,W}{0.82\left(fl.oz./\,drink\right)}\right]^2} \quad \text{for women}$$

where:
- 1σ = one standard deviation
- N = number of drinks
- C_t = blood alcohol concentration in Kg/L
- W = body weight in ounces

3. Confidence Interval for a Population Mean

$$\bar{x} \pm t_{(1-\frac{\alpha}{2})(n-1)df}\,\frac{S}{\sqrt{n}}$$

where:
- $\bar{x}$ = sample mean
- t = from a table of t values for appropriate level of confidence

S = the standard deviation of a single value

4. Accuracy (Systematic Error or Bias)

$$\%SE = \left[\frac{\bar{x} - R}{R}\right]100$$

where: SE = systematic error or bias
$\bar{X}$ = mean results
R = reference value

5. Error Propagation: General Formula for Random Errors

$$S_q = \sqrt{\left[\frac{\partial q}{\partial x}\right]^2 S_x{}^2 + \left[\frac{\partial q}{\partial y}\right]^2 S_y{}^2}$$

where: x and y are independent and
there can be as many terms as there are independent variables

6. Confidence Interval for a Population Mean

$$P\left[\bar{x} - t_{(1-\frac{\alpha}{2})(n-1)df}\frac{S}{\sqrt{n}} \le \mu \le \bar{x} + t_{(1-\frac{\alpha}{2})(n-1)df}\frac{S}{\sqrt{n}}\right] = P$$

Where: μ = true population mean

7. Confidence Interval for a Difference Between Two Sample Means

$$diff \pm t_{(1-\frac{\alpha}{2})(n_1+n_2-2)df}\, SE_{diff}$$

where:

$$diff = \bar{X}_1 - \bar{X}_2$$

$$SE_{diff} = \sqrt{\frac{(n_1-1)S_1^2 + (n_2-1)S_2^2}{n_1+n_2-2}\left[\frac{1}{n_1}+\frac{1}{n_2}\right]}$$

This method assumes equal variance for both variables

8. t-Test For Independent Means Assuming Equal Variances

$$t = \frac{\overline{X}_1 - \overline{X}_2}{SE_{diff}}$$

where: SE_{diff} = standard error (standard deviation) of difference computed as follows

$$SE_{diff} = \sqrt{\frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{n_1 + n_2 - 2}\left[\frac{1}{n_1} + \frac{1}{n_2}\right]}$$

where: the degrees of freedom is: $df = n_1+n_2-2$

For small samples, the Wilcoxon Rank Sum test is a non-parametric equivalent to the independent sample t-test

9. Calculation of Required Sample Size for Paired Data

$$n \geq \left[\frac{\sigma}{\delta}\right]^2 \left[Z_{1-\alpha/2} + Z_{1-\beta}\right]^2$$

where: σ = standard deviation (assumed constant)
δ = critical difference
P = power of the test ($1-\beta$)
β = typically set to 0.20 (a one sided test value)
α = significance level
Z = from the standard normal distribution

10. Water/Air Partition Coefficient for Ethanol

$$K_{water/air} = 23017.268\, e^{-0.0643T}$$

where: T = temperature in celcius

11. t-Test For A Population Mean

$$t = \frac{\overline{X} - \mu}{S_X / \sqrt{n}}$$

where: μ = the population mean
S_X = the standard deviation of a single result

12. Standard Deviation

$$S = \sqrt{\frac{\sum_{i=1}^{n}\left(x_i - \overline{x}\right)^2}{n-1}}$$

13. Coefficient of Variation

$$CV = \left[\frac{S}{\overline{x}}\right]100$$

14. Combining Uncertainty From Two Independent Sources

$$S_T = \sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}$$

where: $S_T =$ total combined uncertainty
$S_1^2 =$ variance from one source
$S_2^2 =$ variance from second source

15. Equation for Computing Total Body Water

$$Men: \quad TBW = 2.447 - 0.09516\,Age + 0.1074\,Height + 0.3362\,Weight$$
$$Women: \quad TBW = -2.097 + 0.1069\,Height + 0.2466\,Weight$$

where: TBW is in liters
Age is in years
Height is in centimeters (2.54cm = 1 inch)
Weight is in kilograms (1Kg = 2.2 lb)

Source: Watson, P.E., Watson, I.D. and Batt, R.D., “Prediction of

blood alcohol concentrations in human subjects”, *J Stud on Alcohol*, Vol.42 No.7, 1981, pp. 547-555.

16. Widmark’s Equation Using Total Body Water

$$N = \frac{\frac{TBW}{0.8}(C_t + \beta t)}{0.82(fl.oz.\ EtOH/drink)}$$

where: N = number of drinks
TBW = total body water in liters
0.8 = fraction of blood that is water (L/L)
C_t = BAC(g/L) at time t and approximated from BrAC measurement
β = elimination rate (g/L/hr)
t = time in hours from first drink
0.82 = density of ethanol (oz./fl.oz.)
28.349 g = 1 ounce by weight

17. Confidence Interval for a Large (n>30) Sample Proportion

$$p \pm Z_{1-\alpha/2}\sqrt{\frac{p(1-p)}{n}}$$

where: p = sample proportion
Z = from the standard normal table for a desired level of confidence
n = sample size

18. Confidence Interval for a Difference Between Large (each n>30) Independent Sample Proportions

$$p_1 - p_2 \pm Z_{1-\alpha/2}\sqrt{\frac{p_1(1-p_1)}{n_1} + \frac{p_2(1-p_2)}{n_2}}$$

where: p_1 = sample 1 proportion
p_2 = sample 2 proportion
Z = from the standard normal table for a desired level of confidence
n_1 = sample 1 size

n_2 = sample 2 size

19. χ^2 Analysis for Independence in a Two-way Table

$$\chi^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i}$$

where: O_i = the observed values in cell i
E_i = the expected values in cell i

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